Daniels, Sybil L. Teaching the topic Color in Hy. Sch. Science classes by means of Natural-Color Photo-slides

BOSTON UNIVERSITY
SCHOOL OF EDUCATION

LIBRARY

Ed.
Service Paper
Daniels, S.L.
1949

The Gift of Sybil L. Daniels

BOSTON UNIVERSITY

SCHOOL OF EDUCATION

Service Paper

TEACHING THE TOPIC "COLOR" IN HIGH SCHOOL SCIENCE CLASSES BY MEANS OF NATURAL-COLOR PHOTOGRAPHIC SLIDES

Text is accompanied by a series of 60 slides.

Submitted by

Sybil Louisa Daniels

(B.S. in Ed., Boston University School of Education, 1936)

In partial fulfillment of requirements

for the degree of Master of Education

1949

Boston University
School of Education
Library

Gift of
Sybil L. Daniels
School of Education
June 13, 1947
30921

APPROVAL PAGE

Service Paper Approved By:

First Reader: John G. Read,
Associate Professor of Science Education

Second Reader: Charles E. Stratton,
Professor of Science and Mathematics

This Lovely World

Oh, I think God must love colors;
For in everything He's made,
He has put some rainbow color--
Some in light and some in shade!
Oh, I like to try to paint them--
Sunsets, oceans, birds and flowers!
Oh, I'm glad God painted all things
In this lovely world of ours.

Emelie Cope Albertson

TABLE OF CONTENTS

	Page
I. THE SCOPE OF THE STUDY	1
Statement of the Problem	1
The problem	1
Selection of the problem	1
The purpose	3
The method	3
Study of the Classes for Which Plan Was Made	5
Extent of study of classes	5
The community and the school	6
Chronological ages	6
English ability	9
Intelligence quotients	12
Interests of pupils	14
Space Provisions and Equipment	15
The classroom	15
Equipment	17
Time Allotment	18
Calendar of events	18
Previous Research	18
The teaching of color	18
Color transparencies	19
Uses of Color Transparencies in Teaching	19

Digitized by the Internet Archive
in 2016

https://archive.org/details/teachingtopiccol00dani

	Page
Growth	19
Further possibilities	20
II. COLOR IN OUR LIVES	21
A Study of the Topic; "Color"	21
General statement	21
Delimitation	21
Dictionary of color terms	21
Probable incidental learning	26
References for Teachers' Use	26
Assignments and Study Aids	29
Interest inventory	30
Key to interest inventory	31
Test answer sheet	32
Science test - Color in Our Lives	33
Problems for study	40
Suggested activities	45
References available for students	47
Experimental materials	49
Presentation to Class by Means of Natural-Color Photographic Slides	49
Color in our lives	49
How we see	51
Light by which we see	52
What color is	57
Color blindness	59

Page

Addition and subtraction of colors 60

Further experiments with colors 63

Symbolism, significance and emotional effects of colors 66

Color in nature 70

Reproduction of colored pictures 76

Color photography 77

Harmonizing colors 79

Media of expression in color 81

Conclusion: Uses of color in our lives 82

III. EVALUATION OF THE STUDY OF COLOR 86

Results of Objective Testing 86

Pretest 86

Final test 86

Growth 88

Constructive Comments 90

Pupil reactions 90

Suggestions for improvement 93

Looking Ahead 94

Future outlook 94

Further research 94

Conclusion 95

APPENDICES

	Page
A. General Purpose Table - Boys	98
B. General Purpose Table - Girls	99
C. Exposure Data on Natural-Color Transparencies	100
D. Exhibit Materials	106
Interest inventory	106
Key to interest inventory	107
Problems for study	108
Suggested activities	112
References available to students	114
Dictionary of color terms	116
Test on color	121

LIST OF TABLES

Number		Page
1.	Distribution of 82 Pupils According to Chronological Age	7
2.	Distribution of Science Pupils According to Ability in English, as Obtained from the Cooperative English Tests A and B, Form T	9
3.	Distribution of Science Pupils According to Intelligence, as Based on the California Short Form Test of Mental Maturity	12
4.	Choice of School Subjects by Science Pupils, as Indicated by Responses on Interest Inventory	15
5.	Distribution of Science Pupils According to Number of Correct Responses on the Pretest on Color	86
6.	Distribution of Science Pupils According to Number of Correct Responses on the Final Test on Color	88
7.	Distribution of Science Pupils According to Growth, as Based on Increase in Correct Responses From Pretest to Final Test	90

LIST OF FIGURES

Number		Page
1.	Distribution of 82 Pupils According to Chronological Age	8
2.	Distribution of Science Pupils According to Ability in English, as Determined by Cooperative English Test A, Form T	11
3.	Distribution of Science Pupils According to Intelligence, as Based on California Short Form Test of Mental Maturity	13
4.	Choice of School Subjects by Science Pupils	16
5.	Whirling Machine	49
6.	Distribution of 82 Science Pupils on Pretest on Color	87
7.	Distribution of 82 Science Pupils on Final Test on Color	89
8.	Distribution of 82 Science Pupils According to Growth Within the Area, as Determined by Pretest and Final Test	91

CHAPTER I

THE SCOPE OF THE STUDY

Statement of the Problem

The problem. The problem for this study is to plan for the teaching of the topic "Color" in high school science classes. The chief teaching aid will be a group of Kodachrome and Ansco transparencies--natural color photographs which have been taken by the author. An attempt will be made to consider color from the educational, scientific, psychological and aesthetic viewpoints.

Selection of the problem. Color is all around us. It is ours to see, to use, to enjoy.

> Color is not only a physical phenomenon; it is the vibration of life itself. Life, light and color express the energy and unity of creation; and color is to life as a ray of light is to sunshine. Every vibration of light, from the celestial blue of the heavens to the darkest lump of coal, is alive with color, and man has only scratched the surface of its infinite possibilities and potentialities.[1]

Recently, through advances in science, man has found color to be a valuable assistant as well as a

---

[1] Bustanoby, J. H., Principles of Color and Color Mixing, McGraw-Hill Book Company, Inc., New York, 1947, Preface.

pleasant companion. Many industries are giving much consideration to the proper use of color in order to effect safer and more harmonious working conditions. Doctors, after careful study of neurotic cases, are treating some of their patients with color. Some school departments are considering and experimenting with more colorful surroundings for children as an inspiration to them which can aid in the learning process. Throughout his school life, each pupil is encouraged in the art classes to experiment with color in the various media. Dr. Landis recommends "guided art experiences which allow the individual sufficient freedom for emotion and reflection and which result, in many cases, in development within the child of a sense of values--aesthetic, psychological and sociological values."[1] Interior decorators, whether professional designers or merely home-makers, are expressing ideas in color and are trying to build color harmonies which serve to add comfort and enjoyment to those individuals living within the home. At times we all have an opportunity to express ourselves in

---

[1] Landis, Mildred M., A Meaningful Method of Art Education on the Elementary School Level, unpublished Ed. D. Thesis, Harvard University, 1947.

color, whether we be engaged in industry, psychology, teaching, art, interior decoration or merely in the selection of pleasing and appropriate color harmonies in our own clothing. Therefore, a keener understanding of its significance and qualities can greatly enrich our experiences with color.

The purpose. The purpose of this study is to present to pupils in high school science classes the varied and interesting scientific facts which should result immediately in more thoughtful use of color as well as increased perception and enjoyment of the color which surrounds them in their daily lives.

The method. Being included in both General Science and Physics programs of high school students, the topic, color, offers a challenge for the planning of a series of activities which will most effectively guide pupils of this age in their acquisition of a knowledge of, and a feeling for, color. With this aim in mind, color photography in the form of natural color photographic slides has been selected as the chief teaching aid. Diagrams, previously drawn on the blackboard, have been carefully and colorfully worked out on charts and then photographed. Some pictures have been taken especially for this study and others have been

selected from a collection of about 2,000 photographic slides previously made by the author. In using these colored slides with the science classes, later to be described, a few were shown each day for five successive days. Discussion accompanied and followed the use of the pictures on each occasion. Other class periods were given to review of the slides, further discussion and related experiments. A comparison of pretest and final test results shows individual growth for the pupils in the science classes to whom this work was presented. More detailed explanations regarding the classes, the plan of the work and the results will follow.

Colored photographic slides seem to have the following advantages as a teaching aid:

1. They add interest to the study.
2. With their use, learning takes place, as indicated by the growth of pupils participating in this study of color.
3. Once carefully drawn and photographed, diagrams are available for use indefinitely.
4. Two-inch slides are much more easily filed for future use than are large bulky charts.
5. Many illustrations are easily made available by slides which cannot be brought into the class room otherwise.

6. Two-inch slides are easily arranged and rearranged according to the needs of the class.

7. Projection of these slides is simple with a small, lightweight projector which may easily be handled by teacher or pupils.

8. For the teacher who can take his or her own pictures on 35 mm. film, there are endless opportunities for illustrations pertinent to the subject.

9. Both slides and projector are much less expensive than motion picture film and projector.

10. These colored slides have an advantage over motion pictures in that one view, or, in this case, color effect, may be seen for the desired length of time, and timing can be varied according to the needs of the class.

11. These teaching materials, slides and projector, are easily transported from room to room or between buildings if necessary.

12. Color photography is exceedingly efficient in recording natural color effects.

Therefore, in the teaching of the topic, color, it is here proposed that it may well be done by means of natural color photographic slides.

Study of Classes for Which Plan Was Made

Extent of study of classes. This study of color is easily adaptable for use in high school Physics classes, but in this case it was presented to the three groups of freshmen enrolled in the General Science classes. By

means of an Interest Inventory, individual pupils were studied as to age, school interests and activities, and outside interests. From the Guidance Department data was obtained regarding reading ability and intelligence quotient. Because of the wide range of ability in each of the three classes, the similarity of distribution of ability in the three classes, and the fact that these groups were not divided according to ability, the studies which follow will be based on the group as a whole, or the total of 82 pupils.

The community and the school. The community is a suburban, residential town with a population of approximately 15,000. The majority of workers commute to nearby Boston for their employ. In the High School there is an enrollment of 750 pupils, 218 of whom are freshmen.

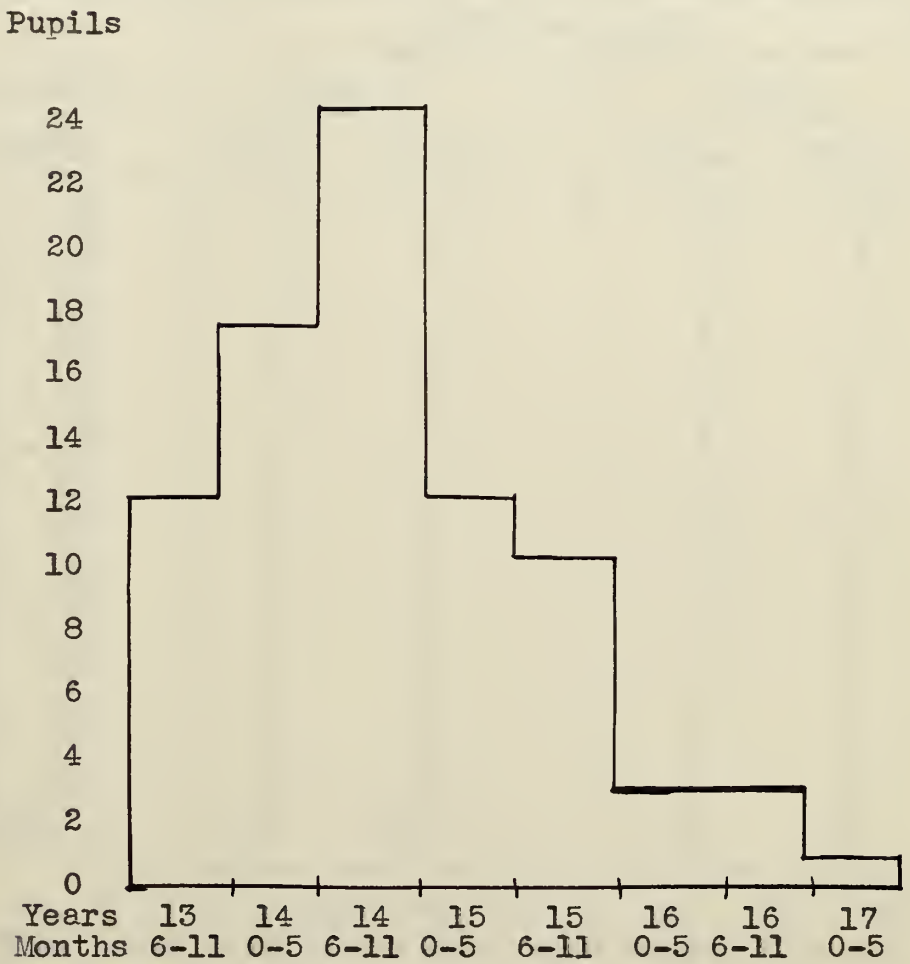
Chronological ages. The ages in the group ranged from 13 years, 6 months to 17 years, 1 month, see Table 1. The range in ages is 3 years 7 months, with a median age of 14 years 8 months.

Table 1. Distribution of 82 Pupils According to Chronological Age.

Age		Number of Pupils		
Years	Months	Boys	Girls	Total
13	6-11	5	7	12
14	0-5	8	9	17
14	6-11	13	11	24
15	0-5	6	6	12
15	6-11	6	4	10
16	0-5	2	1	3
16	6-11	2	1	3
17	0-5	1	0	1
Totals		43	39	82

Meeting the needs of the pupils of varying ages had to be dealt with in planning, since it is very evident that the interests of the boy of 17 years would vary considerably from those of the boys and girls who were under 14. The suggested activities make provision for this difference, as well as the variation of interests between the boys and girls.

Figure 1. Distribution of 82 Science Pupils According to Chronological Age



English ability. In October, 1948, the co-operative English Tests A and B, Form T, were administered by the Guidance Department.

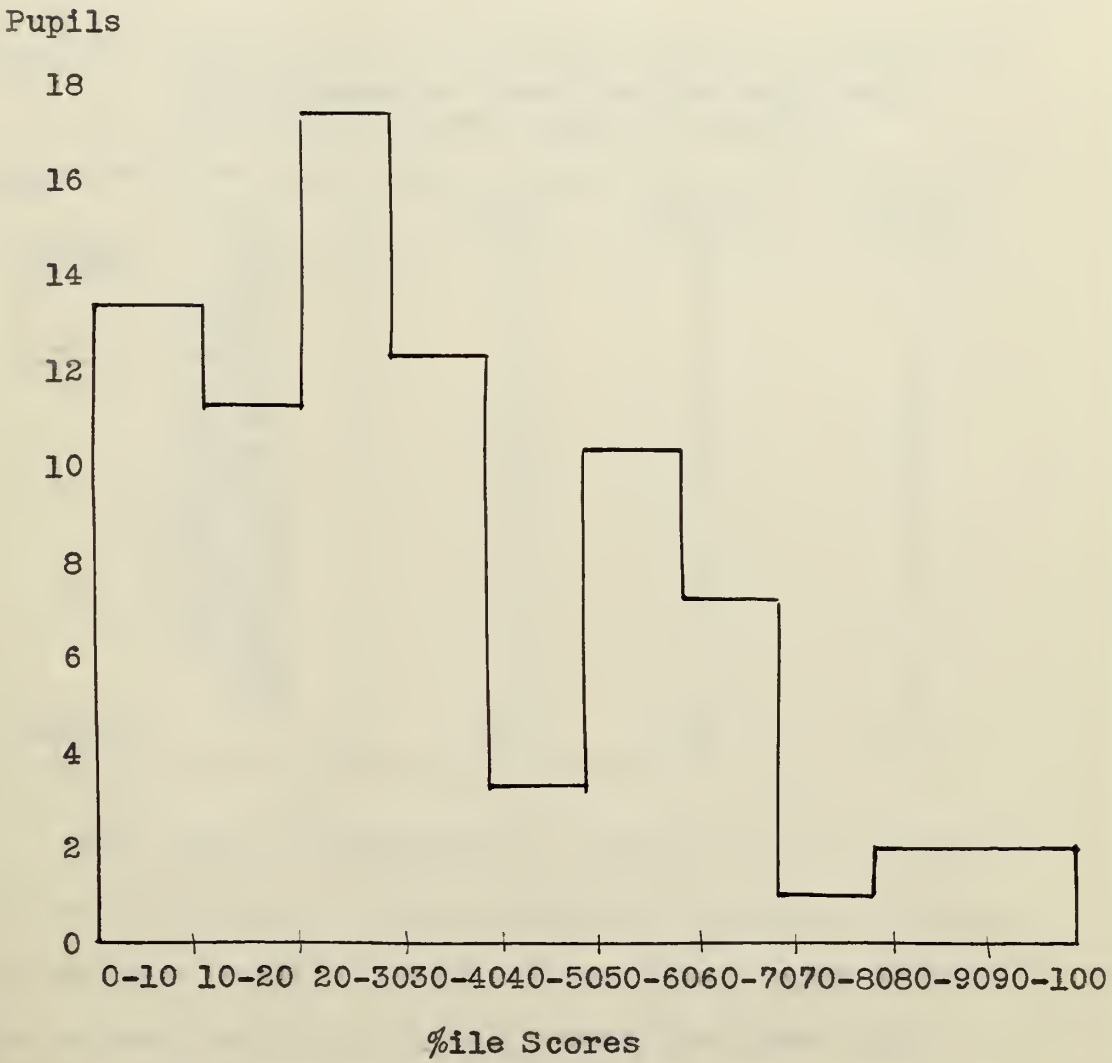
Table 2. Distribution of Science Pupils According to Ability in English as Obtained from the Co-operative English Tests A and B, Form T.

Percentile Scores	Number of Pupils			
	Test A		Test B	
	Boys	Girls	Boys	Girls
0 - 5	3	0	2	2
6 - 10	8	4	5	4
11 - 15	0	0	5	6
16 - 20	5	6	2	2
21 - 25	5	5	5	1
26 - 30	4	3	0	6
31 - 35	3	1	3	2
36 - 40	4	4	5	1
41 - 45	0	0	0	0
46 - 50	3	0	2	0
51 - 55	2	2	3	2
56 - 60	1	5	4	3
61 - 65	1	1	2	2
66 - 70	2	3	2	3
71 - 75	1	0	0	1
76 - 80	0	0	1	1
81 - 85	0	0	1	1
86 - 90	1	1	0	0
91 - 95	0	1	1	0
96 -100	0	1	0	0
Totals	43	37	43	37

From Table 2 it may be seen that there is rather a sharp division in the group at the 40 percentile level. In Test A, on the mechanics of expression, 55 pupils,

or 69% of the Science students are in the lower 40% of the freshman class, while in Test B, on effectiveness of expression, 51 pupils, or 64% of the Science students are in the lower 40% of the freshman class. At this point it is interesting to note that 13 of the Science students are taking the College Preparatory Course while 41 are taking the Commercial Course, and 28 are in the General Course. According to the standards for this English test, 10 of the Science pupils are slightly above normal in both Test A and Test B.

Figure 2. Distribution of Science Pupils According to Ability in English as Determined by Cooperative English Test A, Form T



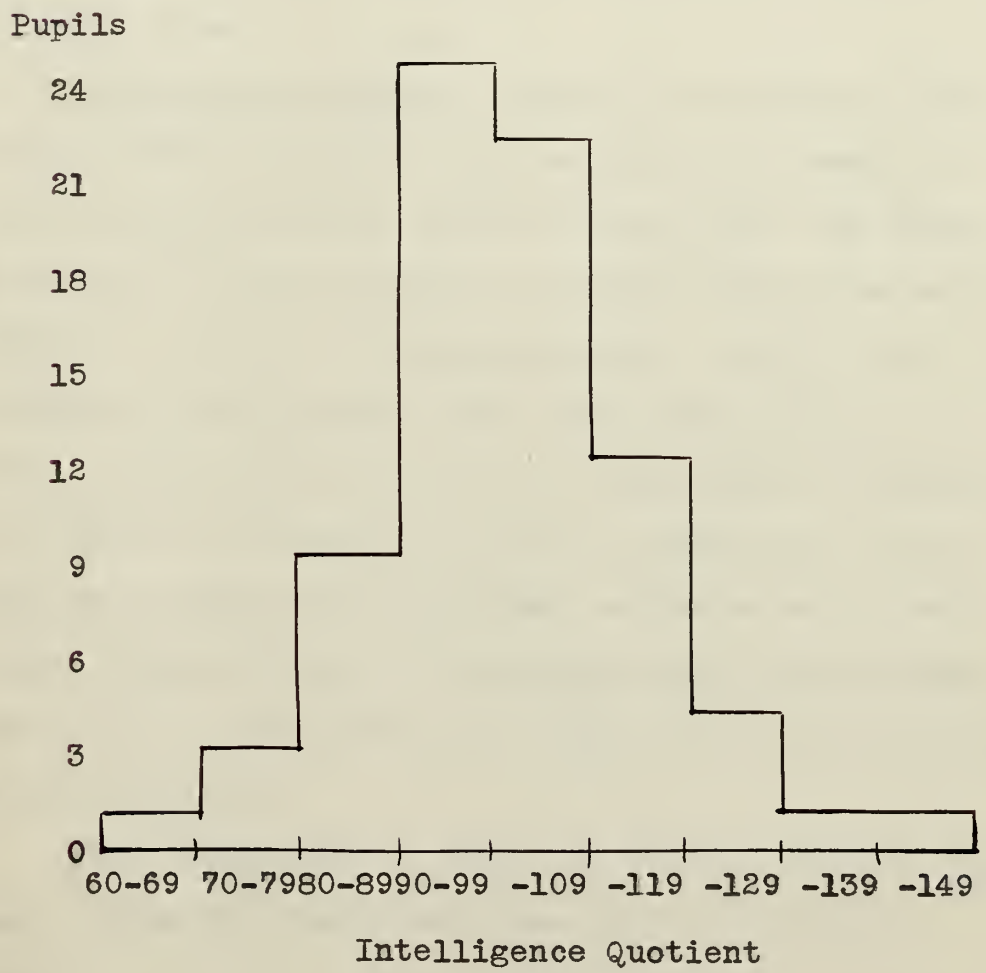
Intelligence Quotients. In November, 1948, the Guidance Department administered to freshmen the California Short Form Test of Mental Maturity, Advanced Short Form, with the following results as far as Science students were concerned.

Table 3. Distribution of Science Pupils According to Intelligence as Based on the California Short Form Test of Mental Maturity.

	I.Q.	Boys	Girls	Total
Below	70	1	0	1
	70-74	1	0	1
	75-79	1	1	2
	80-84	3	3	6
	85-89	1	2	3
	90-94	5	8	13
	95-99	6	5	11
	100-104	10	2	12
	105-109	3	7	10
	110-114	1	3	4
	115-119	5	3	8
	120-124	1	1	2
	125-129	2	0	2
	135	1	0	1
	145	1	0	1
Totals		42	35	77

The range of intelligence quotients in the group is from 69 to 145, with a median of just 100. Forty-six Science pupils, or 60% of the group, come within the normal range with intelligence quotients from 90 to 110, while 13 pupils, or 17%, are below normal; and 18 pupils, or 23%, are above normal.

Figure 3. Distribution of Science Pupils According to Intelligence as Based on California Short Form Test of Mental Maturity



The wide range of abilities, as indicated by the results of both English and Intelligence tests, offers a problem in providing for individual differences of interest and ability. This provision is made through reading and activities suggested in addition to required work, with an opportunity for the completion of original ideas.

Interests of pupils. A study of school and non-school interests of the boys and girls, by means of an Interest Inventory, reveals facts which may serve as an aid in the selection of subject matter to be included in the work on any given area. Of the 82 students in the group, 4 boys and 7 girls felt they were having some difficulty with the study of Science. As a matter of fact, 5 of these 11 pupils are doing well in Science but do not feel satisfied with themselves because there are times when they are puzzled. The other 71 pupils felt that they had no difficulty in studying Science.

When questioned in regard to school subjects liked most and least, the answers were as tabulated in Table 4.

Table 4. Choice of School Subjects by Science Pupils, as Indicated by Responses on Interest Inventory.

	Liked Most			Liked Least		
Subject	Boys	Girls	Total	Boys	Girls	Total
Science	14	14	28	0	1	1
English	2	7	9	27	7	34
Mathematics	12	12	24	6	6	12
History	2	0	2	1	5	6
Civics	4	2	6	6	17	23
Shop	4	0	4	0	0	0
Printing	1	0	1	0	0	0
Physical Ed.	3	2	5	1	0	1

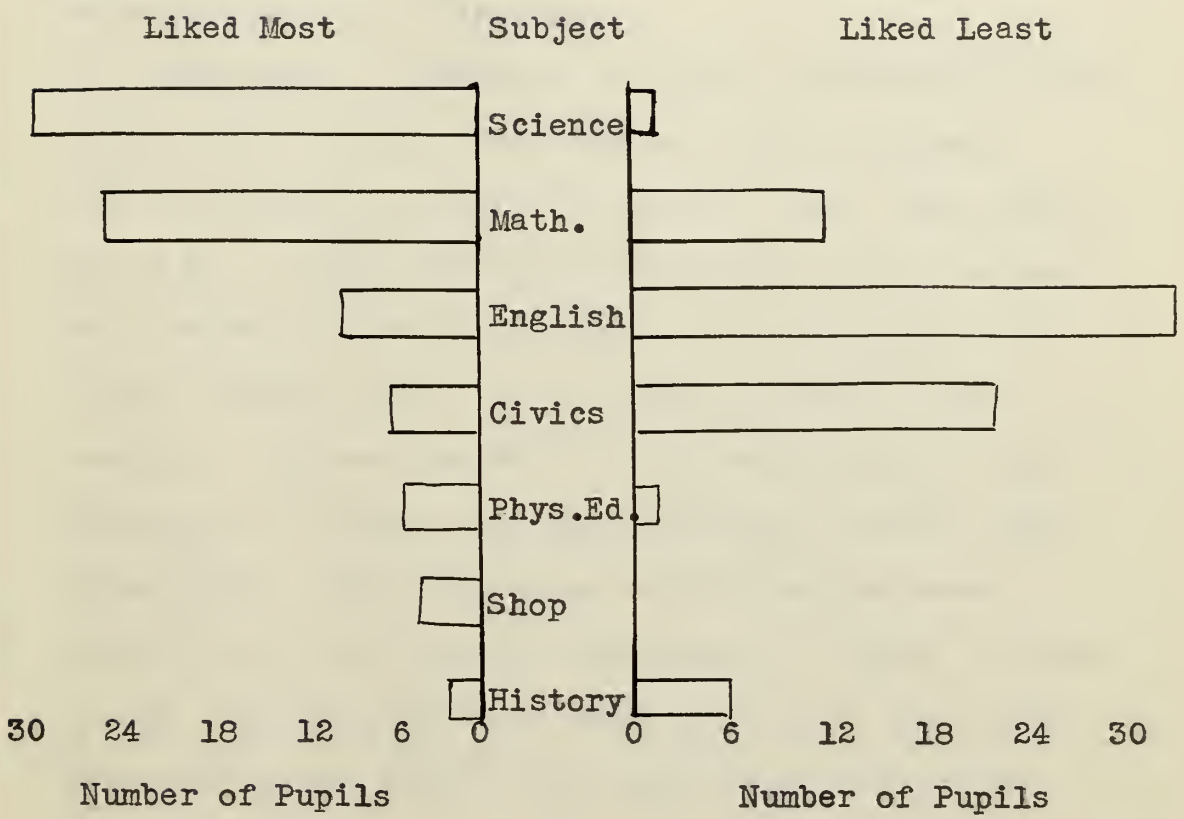
It is interesting here to note that Science and Mathematics far out-distance the other subjects in being liked most, while English, such an important tool in our lives, is least popular.

A survey of school activities showed at least 80% of these Science students participating in one or more of the school athletics, clubs or other activities. About the same proportion of these pupils described hobbies and out-of-school activities that occupy their leisure time.

Space Provisions and Equipment

The classroom. The traditional classroom was provided with 35 desks and seats bolted to the floor. It

Figure 4. Choice of School Subjects by Science Pupils



also contained a science demonstration table and a wall screen with aluminum finish. Eight large windows with translucent shades made the room too light for color projection. Therefore, arrangements were made for use at certain times of a basement room directly below this first-floor class room which could be much more effectively darkened.

Equipment. A Society of Visual Education 2" x 2" slide projector was available as school equipment but the teacher preferred to use her own, more powerful T.D.C. (Third Dimensional Company) projector and her own white five-foot screen. The 60 slides used in the teaching were all made and provided by the teacher. Classes passed to the "dark room" for the showing of pictures and some discussion, while other experiments, demonstrations and discussions were carried on in the regular class room. Typing of master copies and duplicating of study pages for the pupils was done by the teacher with materials provided by the school.

A class room science library was organized containing the references listed on pages 47 and 48, some of the books being provided by the school and some by the teacher. The school and public libraries also served

as sources of information for both pupils and teacher.

Time Allotment

Calendar of Events. On December 1, 1948 the pre-test on the study of Color In Our Lives was taken by the pupils, while actual teaching of this topic began on Monday, December 5. During the ensuing two and a half weeks, six one-hour periods and five forty-five-minute periods were devoted to the work, as well as the time allotted for homework. The final test was given in two parts on two consecutive days. A group of exceedingly colorful and interesting notebooks, made and illustrated by the students, was passed in as school closed for vacation on December 23. More time could have been used, but considering the extent of the freshman science program it seemed best to limit the study of color to three weeks. These plans and natural color photographic slides could also be used to advantage in high school Physics classes; and, in the same time, a growth of pupils to still higher levels should be realized.

Previous Research

The teaching of color. This topic has been very

efficiently organized for Art classes of grade nine by Edith Stewart Chase.[1] As an accompanying series of activities for Science classes, this plan for teaching the topic color by means of natural color photographic slides is offered. See Chapter II for the complete plan.

Color transparencies. No research has been located as yet on the use of color transparencies in teaching. However, the writer did hear Mr. Vinton R. Rawson of White Plains High School, White Plains, New York, speak of using 2" x 2" slides in the teaching of Chemistry. He has built a library of about 2,000 such slides, some colored and some black and white, to be used in this way. He favors them in preference to slide film because of the ease with which rearrangements of illustrative teaching materials may be made. This is indeed a new and open field of research with unlimited possibilities.

Use of Color Transparencies in Teaching

Growth. Significant growth of the individuals in this area, when teaching the topic color with the use

---

[1]Chase, Edith Stewart, A Course in Art for Grade Nine (with unit organization of the topic, Color), unpublished Ed. M. Service Paper, Boston University School of Education, 1946.

of natural color slides, is adequate in the writer's mind to warrant future use of the same series of slides for other classes and by other teachers. The plans and information correlative to the color transparencies presented herewith are given in careful detail in Chapter II in order that they may be used by others as well as the writer.

Further possibilities. Though this study is confined to the topic color, which it is fair to assume can be best illustrated in color, there are many possibilities for teaching in the same manner in other fields as well as Science. Color usually adds to the interest, gives a truer impression and aids in stressing important points. In these cases natural color photographic slides could be used easily and effectively.

CHAPTER II

COLOR IN OUR LIVES

A Study of the Topic: "Color"

General Statement. No uncommon intelligence is needed for the perception and enjoyment of color. With color continuously surrounding us, we may unconsciously take it for granted or we may add to our enjoyment by increasing our knowledge and powers of observation. In this study some of the interesting facts are stressed and illustrated in color for the simple purpose of arousing a keener enjoyment of the Color In Our Lives.

Delimitation. The delimitation of the subject in this case is offered in the form of a Dictionary of Color Terms. When working with the pupils, this list of terms was given to them with the Problems for Study. As the work progressed, the boys and girls filled in the definitions and later used them for study and review.

Dictionary of color terms.

absorb - to take in, as in the case of red light being absorbed by a green object while green light is being reflected.

achromatic - devoid of hue, colorless.

addition of colors - mixing of colored light, as with spot lights.

advancing colors - hues which seem to be relatively nearer to the observer, the warm colors in which red-orange predominates.

analagous colors - colors closely related to each other, such as blue, blue-green and green.

blending - process of mixing one color with another, method of mixing pigments or lights.

black - absolute lack of color, due to fact that all colors of white light are absorbed.

bright - term applied to vivid intense colors.

brilliant - very bright.

chroma - intensity or purity. Strong chroma is pure color from the spectrum. Weak chroma is obtained by mixing in a little of the complementary color, thereby graying the original hue.

color - the general sensation perceived by the eye and brain as a result of the vibrations of light. Differing frequencies and wave lengths produce the various colors.

color circle - a band of the spectrum colors bent into a circle, whereupon the complements are directly opposite each other.

color harmony - any color effects which are consistent with nature and, because of this,are pleasing to see. Any color harmony includes unity, consistency and fitness, as does any other harmony in life.

complementary colors - any two opposite hues that furnish completeness to each other. Complementary colors in lights together produce white, while complementary colors in pigments mixed together produce neutral gray.

cool colors - any hues in which blue predominates. Being the colors associated with ice and snow, they give us a feeling of coolness.

dark - low in value, shades toward black.

deep - intense or strong colors with no black.

diffused light - scattered light, light reflected in all directions.

dominant color - an outstanding color, one which predominates.

dull - grayed or neutral quality, such as dusty pink.

full color - a color of great purity, strength and intensity.

hue - a color, as red, yellow or green.

infrared - invisible energy waves which are somewhat longer than those of visible red light. Infrared rays affect some camera films.

intermediate - colors in between the spectrum hues.

iridescence - the appearance of color where no pigment is present. This opalescent color is the result of refraction caused by the structure of the reflecting surface. Some examples of iridescence are the colors in soap bubbles, oil or water films, sea shells, ceramic glazes and the feathers of birds.

monochromatic - term applied when one color is combined with different tints and shades of that color.

neutral - a dull or grayed color.

opaque - having the quality of not permitting light to pass through.

opposite colors - complementary colors.

pigment - any coloring material of animal, mineral or vegetable origin.

primary colors - basic colors, or those of first importance, unrelated to and not produced by mixing any other colors. In pigments, red, yellow and blue are primary colors. In light, the primary colors are red, green and blue. If spot lights of these colors are superimposed they add up to, or result in, white light.

prism - a transparent optical instrument usually of glass and triangular in shape. When sunlight passes through a prism, the rays are bent twice so that they separate into the solar spectrum.

rainbow - a spectrum formed when rays of sunlight are refracted and reflected by raindrops.

receding colors - hues which seem to be distant or far from the observer, cool colors in which blue predominates.

reflection - turning back of light rays from a surface, as a green object seen by green light reflected.

refraction - the bending of light rays as they pass from one substance to another of different density. The angle of refraction varies with the different colors because of the differing rates of vibration of the light waves of each color.

secondary colors - a combination or mixture of any two primary colors in equal proportions, orange, green and purple.

shade - a deep or dark value of a color.

spectrum - the band of colors produced when a ray of sunlight is bent by a glass prism so that its colors are separated from one another.

spectroscope - an optical instrument for the study of spectra, used in identification of elements by means of their spectra.

spectrophotometer - an optical instrument used in the scientific measurement of color. It can distinguish between several million colors.

tint - a pale or light value of a color.

tertiary color - a color produced by mixing the three primary colors, as brown.

transmit - to cause to pass through, as red light transmitted by red glass.

transparent - admitting light to pass through.

ultraviolet - invisible energy waves which are next shorter than violet light rays. They have certain health-giving qualities.

value - a term used to distinguish light, pale colors from dark ones, or tints from shades; gradations of light and dark.

vibrating colors - complementary colors of full intensity which give the illusion of vibrating.

vibration - a rapid motion to and fro. Vibration rates in the visible spectrum go into trillions of vibrations per second.

vibrant colors - a method of applying colors in art whereby small patches of color are placed side by side to produce a live vibrant tone of color instead of the flat effect obtained by mixing.

warm colors - hues in which red-orange predominates. The term warm is applied because of feeling of warmth and association with fire and sunlight.

wave length - the distance between vibrations of energy, or the light that produces visible color sensations in the eye. Wave lengths in light are measured in millimicrons (the millionth part of a millimeter). For instance, the green in the spectrum has a wave length of from 505 to 533 millimicrons, while red-orange has the longest wave length of the visible spectrum and violet has the shortest.

white - the sum of all colors, all colors reflected and none absorbed.

Probable incidental learning. With interest and attention aroused through this study, pupils should become more conscious, and therefore more appreciative, of the meaning and symbolism of colors as they see them used, as well as becoming more alert to the meaning of colored signals. Realizing the importance of color and its effects upon people, they should give more careful consideration to choice of colors in clothes, in the home, or for any purpose for which they may be selecting colors.

References for Teachers' Use

1. Abbott, Arthur G., The Color of Life, McGraw-Hill Book Company, New York, 1947, 287 pages. This book gives extensive information regarding color. It includes many more topics than those touched upon in this thesis. It appeals to me as an excellent reference book on the subject

of color for all art and science teachers, as well as those of any occupation who may be interested in the use and effects of color.

2. Basic Photography, War Department Technical Manual, TM1-219, War Department, Washington, July 1, 1943, 342 pages. Chapter 13, on Color Photography, explains process and technique.

3. Bond, Fred, Kodachrome and Ektachrome From All Angles, Camera Craft Publishing Company, San Francisco, California, 1947, 244 pages. This book is a complete working guide on everyday problems in Kodachrome, Ektachrome and Kodacolor photography for stills and movies. Its detailed information and many clear diagrams should prove most helpful to the experienced as well as beginning photographers while the many full color reproductions of the author's own Kodachromes are an inspiration to all who read the book. It is recommended for those who wish to begin or improve color photography.

4. Bustanoby, J. H., Principles of Color and Color Mixing, McGraw-Hill Book Company, New York, 1947, 131 pages. An exceedingly interesting book with many colored illustrations. Pigments and media, as well as color mixing, are covered in great detail. Information is also given on the origin of color, color sensation, color psychology, uses of color and the various color systems for study and classification of colors.

5. Germaine, Ina M., Handbook of Color and How to Use It in Your Home, Robert M. McBride and Company, New York, 1946, 108 pages. As the title indicates, this book gives many interesting and helpful suggestions regarding color harmonies to be used in the home.

6. Graves, Maitland, The Art of Color and Design, McGraw-Hill Book Company, New York, 1941, 292 pages. Nearly half the book is given over to the subject of color and it is particularly helpful for its explanation of the measurement of color. The spectrophotometer detects color differences much more readily and minutely than the human eye. This book explains how such measurement can be expressed. It also clearly and concisely explains many of the fundamental ideas about color, as well as including an interesting section on associations and symbolism of colors.

7. Henney, Keith, Color Photography for the Amateur, Whittlesey House, McGraw-Hill Book Company, New York, 1948, 355 pages. For the inexperienced person who is contemplating experiments in the field of color photography, this book will answer many questions regarding value of color photography, expense, cameras, lenses, films, filters, exposure meters, correct exposure, flood lights, synchronized flash lights, color processes, color prints, black and white prints from color transparencies, and many other phases of this type of photography.

8. Kandinsky, Wassily, On the Spiritual in Art, first complete English translation, Solomon R. Guggenheim Foundation, for Museum of Non-objective painting, New York, 1946, Hilla Rebay, Editor, 152 pages. Writing in 1910, Kandinsky was among the first to stress the abstract use of form and color in art. Chapters 5, The Effect of Colour, and 6, The Language of Form and Colour, are particularly interesting here in relation to the study of our emotional response to color.

9. Martini, Herbert E., Color, Bridgman Publishers, Pelham, New York, 1946, 63 pages. Included here one finds a very helpful study of tools of the artist--kinds of paints, pigments of both temporary and permanent nature, and painting grounds. Color theory is discussed

from the point of view of the 3 primary and 6 primary plans. Suggestions are given for the use and mixing of pigments in the painting of landscapes, still life, flowers and portraits.

10. Miller, Thomas H., and Brummett, Wyatt, This is Photography, Garden City Publishing Company, Inc., Garden City, New York, 1947, 260 pages. Chapters 11 and 12 on Color Photography explain the intricacies of color film and give many helpful suggestions for taking natural color pictures.

11. Stewart, Oscar M., and Cushing, Burton L., Physics for Secondary Schools, Ginn and Company, Boston, 1941, 760 pages. Chapter 27, Dispersion and Color Phenomena, and Nature of Light, states briefly and clearly many of the fundamental ideas regarding color. A simple explanation of color photography is also included. Other secondary Physics texts would be helpful in the same way.

Assignments and Study Aids

Interest inventory. In order to become better acquainted with pupils' interests and activities and thereby to be better enabled to meet their needs, an Interest Inventory was used. This included not only questions to be answered by each individual, but a series of spaces in which the teacher could record information. In the end, each page carried a fairly complete story of a student. The Interest Inventory, which appears on the next page, is followed by a Key which explains its use.

a____ b____ c____

Interest Inventory

1. Name _____ 2. Address _____

3. Do you have any difficulty in studying Science? ____

4. If so, explain. _____

_____

5. Why did you elect Science? _____

_____

6. What school subject do you like most? _____

7. What school subject do you like least? _____

8. In what school activities do you participate? _____

_____

9. Do you have a hobby or special interest? _____

10. If so, describe it. _____

_____

11. What else do you do in your leisure time? _____

_____

_____

12. How old are you? _____ years _____ months.

d_____ g_____ j_____

e_____ h_____ k_____

f_____ i_____ l_____

m_____

Key to Interest Inventory

a. Division, or class, of Science pupils.

b. Number in alphabetical arrangement of division.

c. Number in alphabetical arrangement of three divisions of Science students.

d. Chronological age.

e. Mental age.

f. I. Q.

g. Achievement - grade level.

h. English comprehension test - percentile position in entire freshman class of 218 pupils.

i. I. Q. percentile position in entire freshman class.

j. Pretest on Color (number of correct answers).

k. Final test on Color (number of correct answers).

l. Growth in this area.

m. Growth in this area - numerical position in Science group of 83 pupils.

COLOR IN OUR LIVES — TEST ANSWER SHEET

Part 1	Part 2	Part 3	Part 4
1._____	1._____	1._____	1. T F _____
2._____	2._____	2._____	2. T F _____
3._____	3._____	3._____	3. T F _____
4._____	4._____	4._____	4. T F _____
5._____	5._____	5._____	5. T F _____
6._____	6._____	6._____	6. T F _____
7._____	7._____	7._____	7. T F _____
8._____	8._____	8._____	8. T F _____
9._____	9._____	9._____	9. T F _____
10._____	10._____	10._____	10. T F _____
11._____	11._____	11._____	11. T F _____
12._____	12._____	12._____	12. T F _____
13._____	13._____	13._____	13. T F _____
14._____	14._____	14._____	14. T F _____
15._____	15._____	15._____	15. T F _____
16._____	16._____	16._____	16. T F _____
17._____	17._____	17._____	17. T F _____
18._____	18._____	18._____	18. T F _____
19._____	19._____	19._____	19. T F _____
20._____	20._____	20._____	20. T F _____
21._____	21._____	21._____	21. T F _____
22._____	22._____	22._____	22. T F _____
23._____	23._____	23._____	23. T F _____
24._____	24._____	24._____	24. T F _____
25._____	25._____	25._____	25. T F _____

1 2

SCIENCE TEST COLOR IN OUR LIVES

Part 1

Completion Test - In the following statements a word or phrase has been omitted. Write the proper word or phrase on the line of the same number in Column 1 of the answer sheet.

We see most objects around us by ___1.___ light.

The most restful and soothing color of all is ___2.___

When light rays are bent to a new course we say they are ___3.___

A ray of sunlight passing through a triangular prism is bent in such a way as to form the ___4.___

In the case of the prism, the ___5.___ rays are bent the most, while the ___6.___ rays are bent least.

Color is the interpretation by the brain of the sensation caused by certain ___7.___

The measurement of color according to its position in the scale from light to dark is known as ___8.___

An object which appears green is absorbing ___9.___ light and reflecting ___10.___ light.

When mixing paints, we think of red, yellow and blue as ___11.___ colors.

Orange and yellow are known as ___12.___ colors because they are near each other and ___13.___ colors because of their apparent temperature.

Secondary colors are orange, purple and ___14.___

Blue, indigo and purple are ___15.___ when compared with the warm colors, and are called ___16.___ colors because of their appearance of being at a distance.

6 3

5 4

The color which symbolizes courage and vigor is __17.__

The colors of a sunset are caused by __18.__ of the sunlight.

People who cannot distinguish between red and green are said to be __19.__

When spot lights of the three primary colors are focused on the same spot, the resulting light is __20.__

A red rose and its leaves give us a(n) __21.__ color harmony while the yellow daffodil and its leaves show an example of a(n) __22.__ color harmony.

When the sun's rays are refracted and reflected by the rain drops, a __23.__ is formed.

Chlorophyll causes the __24.__ color which we see in nature.

Blue and red paint may be mixed to produce __25.__

Part 2

Multiple Choice Test - In Column 2 on the answer sheet place the number of the term in Column B which is most closely associated with the word in Column A.

Column A	Column B
1. Protective coloration	1. flowers 2. young birds 3. red 4. clothing
2. Analagous colors	1. red and orange 2. red and green 3. red and yellow 4. red and blue
3. Spectrum	1. chroma 2. value 3. hue 4. shade
4. Red dress	1. red absorbed 2. orange absorbed 3. red reflected 4. green reflected

5. Hue	1. black 2. yellow-green 3. white 4. colorless
6. Spectrum	1. reflect 2. see 3. shine 4. refract
7. Red	1. danger 2. caution 3. pause 4. go
8. Intermediate color	1. yellow 2. green 3. yellow-green 4. blue
9. Red, orange, yellow	1. cool 2. warm 3. receding 4. clear
10. Subtraction of color	1. reflection 2. refraction 3. absorption 4. addition
11. Green	1. subduing 2. cheering 3. arousing 4. quieting
12. North room	1. green 2. blue 3. rose 4. violet
13. South room	1. green 2. red 3. orange 4. yellow
14. Prism	1. rainbow 2. spectrum 3. chroma 4. value
15. Fifty years	1. silver 2. white 3. gold 4. orange
16. Complementary colors	1. red and yellow 2. blue and orange 3. green and blue 4. yellow and brown
17. Brain	1. sight 2. hues 3. interpretation 4. gray
18. Color blindness	1. confusion of colors 2. lack of color sense 3. inability to see 4. addition of colors

19. Green (book) 1. transmitted 2. reflected 3. absorbed 4. mixed

20. Blue-green 1. primary 2. secondary 3. tertiary 4. intermediate

For the next five questions refer to the colored border around page one and give the number of the color which is

21. Warm and cheerful

22. Cool and restful

23. Receding and subduing

24. Arousing, inspiring, warm and vigorous

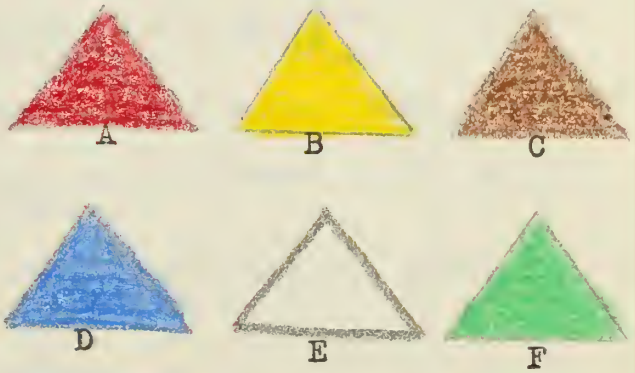
25. Stimulating

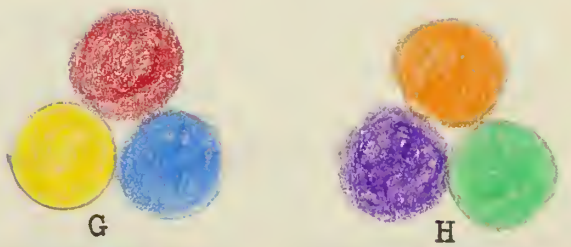
Part 3

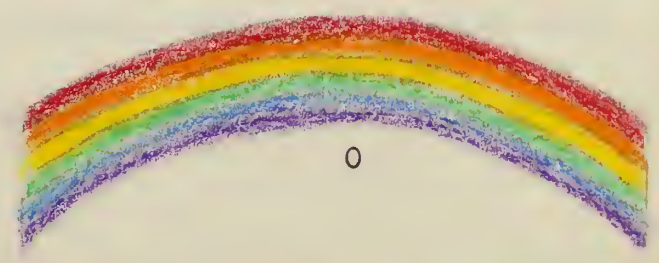
Matching Test - Read the title in Column A; then select a diagram which illustrates the title. The letter of the diagram is your answer to be placed beside the proper number in Column 3 on the answer sheet. A letter may be used more than once.

Column A

1. Complementary colors
2. Primary colors
3. Vibrating colors
4. Secondary colors
5. Spectrum colors
6. Intermediate colors
7. Warm colors
8. More than 3 hues
9. Variations in chroma
10. Cool colors
11. Value variations only
12. Advancing colors
13. Analagous colors
14. Receding colors
15. Rainbow colors
16. Tertiary color
17. Monochromatic colors
18. Color symbolizing envy
19. " " safety
20. " " 50 years
21. " " danger
22. " " purity
23. " " loyalty
24. Transmitted by red glass
25. Reflected by blue cloth







Part 4

True-False Test - Read each statement carefully. If you think it is true, circle the T. If you think it is false, circle the F. If you think a statement is not true, you must also supply the correct word which should go in place of the word underlined.

Place your answers in Column 4 of the answer sheet.

1. Brown is called a tertiary color because it may be mixed from the three primaries.

2. When we mix violet with yellow and keep the value the same, we are changing the hue.

3. Red glass absorbs red light.

4. Green grass absorbs green light.

5. An orange sweater absorbs blue light.

6. The colors seen in the flame of a campfire are known as warm or advancing colors.

7. The colors of snow and ice are cool or receding colors.

8. Color is measured scientifically by considering its hue, value and chroma.

9. According to the theory of color vision, the eye contains nerve endings, called cones, which are sensitive to the primary colors.

10. Color affects our emotions.

11. In selecting colors for our clothing we should be sure that they are suited to the purpose as well as pleasing.

12. Ultra-violet waves are shorter and travel faster than visible light waves.

13. Infrared waves are invisible but will affect some camera films.

14. Visible light waves are energy waves, like radio waves and X-rays.

15. The human eye can distinguish about 200 colors, including all tints and shades.

16. A triangular piece of glass which can separate sunlight into its spectrum colors is called a crystal.

17. Primary colors in lights are the same as primary colors in pigments.

18. Green, which is found so extensively in nature, has a cheering effect upon the emotions.

19. Purple is the color of royalty, probably because it was so costly and difficult to obtain in early days.

20. Color-blind persons are barred from some kinds of work because they have difficulty in distinguishing between purple and yellow.

21. If we mix red with orange, or blue with purple, we obtain secondary colors.

22. When a green coat is illuminated by a red light only, the coat appears to be red.

23. Brilliant red and blue, placed side by side, seem to vibrate.

24. A piece of cloth with its design printed in three shades of brown is said to have an analagous color harmony.

25. In painting school rooms we should consider emotional effects of the colors to be used.

STIMULATING

CHEERING

QUIETING

AROUSING

SOOTHING

SUBDUING

COLOR IN OUR LIVES

Problems for Study

For help in answering these questions you may refer to books in the class room and any reference books you may have at home. You should also get many helpful ideas from the pictures shown in class.

---

1. Color the border of this page, starting with red for arousing, orange for cheering, yellow for stimulating, green for quieting, blue for soothing, and violet for subduing. Blend the two neighboring colors together between the terms.

2. What color or colors do you like best for each of the following purposes: your clothing, your living room, your kitchen, your bedroom, your house (outside), your car, your school room, and flowers or pictures to be enjoyed?

3. Explain how you can see the flame of a burning candle.

4. Explain how you can see the paper on which you are writing.

5. Explain how you can see the stained glass window in your church.

6. Draw a diagram to show what happens to a ray of sunlight when it passes through a prism.

7. What does "refract" mean?

8. What color is refracted most in passing through a prism?

9. What color is refracted least in passing through a prism?

10. Light waves are electromagnetic waves of energy. What other electromagnetic waves can you name?

11. What are ultraviolet rays?

12. What are infrared rays?

13. What is the spectrum?

14. In the spectrum the colors are not found in equal parts. Which color occupies the greatest area? Which is found in the smallest area?

15. What is a spectroscope?

16. What is a spectrophotometer?

17. About how many tints and shades of the various colors can be distinguished by the human eye? How many can be distinguished by the spectrophotometer?

18. In the scientific measurement of color, what three qualities are considered?

19. Explain the meaning of the term "hue" and give four examples. (Colored illustrations are best.)

20. Explain the meaning of the term "value" and illustrate your answer.

21. What does chroma mean? Make a little sketch which shows variation in chroma.

22. What is color? Can there be color without the presence of an eye and brain?

23. Briefly explain the theory of how we see color.

24. If an opaque object appears to be blue, what colors are being absorbed and what reflected?

25. Answer the same question for green, yellow and purple objects.

26. If stained glass appears red, what colors are being absorbed and what are transmitted?

27. Answer the same question for blue, green and orange glass.

28. If you were color-blind what difficulty would you have?

29. Is there any kind of work which should be avoided by color-blind people? Why?

30. In stage lighting, what colored spot lights may be added to produce white light?

31. What are the primary colors in lights?

32. What effect is produced by addition of colors when the spectrum colors from a prism are passed through a second prism?

33. What happens when the spectrum colors are blended on a rotating machine?

34. Why does the mixing of pigments produce the subtraction of colors?

35. Name and illustrate the primary colors in pigments.

36. What are the secondary colors? Illustrate your answer.

37. Give four examples of intermediate colors. Illustrate.

38. What is meant by a tertiary color? Mix paints to produce a tertiary color.

39. When light is transmitted by green glass, what subtraction has taken place? Answer the same question for purple glass.

40. Are absorption and subtraction of color the same?

41. Why are warm colors so called? Name or illustrate them.

42. Why are cool colors so called? Name or illustrate them.

43. What are advancing colors? Receding colors?

44. What effect is produced when brilliant red and green are placed side by side?

45. How do you explain the effect known as after image? Where have you seen one other than in the lesson?

46. Referring to the border on Page 1, list the emotional effects which are thought to be produced by each color.

47. How are colors used by some doctors in treating patients?

48. List the characteristics or ideas which are symbolized by each of the spectrum colors and brown, black, white, gold and silver.

49. Explain the symbolism of the colors in our flag.

50. What causes the brilliant colors of the sunrise and sunset?

51. Explain the formation of a rainbow.

52. What produces the green coloring in leaves?

53. Explain one theory by which scientists account for the autumn colors of leaves.

54. Why do the sky and large bodies of water appear to be blue when we know that air and water are both colorless?

55. What causes the color in flowers?

56. List some of the most colorful insects. Make colored sketches of two or three of them, if you wish.

57. How do we account for the colors in the feathers of birds?

58. What is iridescence? How is it explained scientifically?

59. In printing colored pictures for calendars, magazines, etc., what process is used? Explain it briefly.

60. What is meant by a color harmony?

61. Give examples or illustrations of complementary, monochromatic and analagous color harmonies.

62. Study the color harmony of the predominating colors on one room of your home and describe it here.

63. Where do we use warm colors in the home? Cool Colors? Why?

64. What color harmony do you like best in your clothing? If you know why you like it best, explain.

65. Make a list of the uses of color--just as many as you can think of--in our homes, schools, industry and all around us.

66. In what colors would you like to see this class room painted? Why?

67. List some of the advantages of color photography.

68. Explain, as briefly as possible, the color photography process by which we make slides, like those used in class, and the many colored movies which we enjoy so much today.

COLOR IN OUR LIVES

Suggested Activities

You may carry out one or more of these suggestions, if you wish, or work on other ideas of your own.

---

1. Design a suitable and attractive cover for your study of Color In Our Lives.

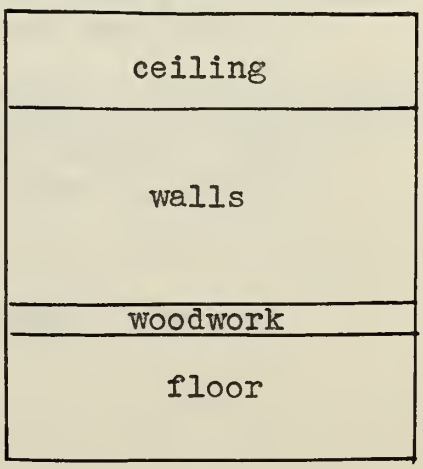
2. Make a special study of The Sources of Pigments and Dyes.

   List the various colors and give the sources from which we obtain the coloring material for each. Tell any interesting incidents which you may find regarding the discovery of any of these materials. Reference: Bustanoby, J. H., Principles of Color and Color Mixing, Mc-Graw Hill, New York, 1947, pages 9 to 17.

3. Make a list of the various Media of Expression in Color and write one or more sentences about each. Illustrate as many as possible, if you wish.

4. Experiment, just for fun, with one or more of these media. Include the results of your experiments in your notes, if you can.

5. A. Plan the color scheme for a room in your home. Arrange the samples of the colors on a full page, arranged in a manner similar to this diagram.

   B. On a second page, show the colors to be used in furniture and other accessories.

6. Plan color schemes for all the rooms of your home and show sample colors in arrangements similar to this one suggested for 5A. Explain why certain colors are selected for each room.

7. Plan the winter wardrobe you would like to have, showing color harmonies for dress clothes, school clothes and sport clothes.

8. Find, and mount in your notebook, pictures which show protective coloration.

9. Arrange a page showing spectrum and intermediate colors illustrated by flowers. You may sketch the colored pictures of flowers or cut them from magazines and seed catalogs.

10. Arrange a page showing all of the colors illustrated by fruits or vegetables.

11. Experiment with color photography yourself.

12. Arrange a series of samples of cloth, wall paper, or other materials and tell the color harmonies you find in them.

13. What other possibilities can you see for the use of colored slides like those shown in this study of color?

14. Make colored sketches to show Color in Nature.

15. Plan a flower garden. Draw a plan showing the flowers to be used and the color scheme they will present.

16. Plan the design and show color harmony to be used in an afghan, bed spread, cloth for overdrapes or any other purpose, an automobile (outside and inside), wall paper, or any other product which must be designed before being manufactured.

Your Own Suggestions

REFERENCES AVAILABLE FOR STUDENTS

1. Beauchamp, Mayfield and West, Science Problems, Book 3 Scott Foresman and Company, New York, 1938.

2. Black, N. H., College Physics, MacMillan Company, New York, 1943.

3. Butler, A. M., Foundations of Physics, M. Barrows and Company, Boston, 1935.

4. Caldwell and Curtis, Introduction to Science, Ginn and Company, Boston, 1929.

5. Caldwell and Curtis, Science For Today, Ginn and Company, Boston, 1939.

6. Clement, Collister and Thurston, Our Surroundings, An Elementary General Science Book, Iroquois Publishing Company, Inc., Syracuse, New York, 1928.

7. Davis and Sharpe, Science, a Story of Progress and Discovery, Henry Holt and Company, New York, 1943.

8. Fuller, Brownlee and Baker, First Principles of Physics, Allyn and Bacon, Boston, 1932.

9. Gruenberg and Unzicker, Science in Our Lives, World Book Company, New York, 1938.

10. Hunter and Whitman, Doorways to Science, American Book Company, Boston, 1947.

11. Hunter and Whitman, My Own Science Problems, American Book Company, Boston, 1935.

12. Hunter and Whitman, Problems in General Science, American Book Company, Boston, 1930.

13. Lincoln Library, Frontier Press Company, Buffalo, New York, 1926.

14. Powers, Neuner, Bruner and Bradley, Using Our World, Ginn and Company, Boston, 1941.

15. Stewart, Oscar M., Physics, A Textbook For Colleges, Ginn and Company, Boston, 1944.

16. Stewart and Cushing, Physics For Secondary Schools, Ginn and Company, Boston, 1941.

17. Watkins and Perry, Science For Human Control, MacMillan Company, New York, 1940.

18. Webster's New International Dictionary, G. and C. Merriam Company, Springfield, Massachusetts, 1937.

19. Willard, Lester R., Experiences in Physics, Ginn and Company, Boston, 1943.

20. Wood and Carpenter, Our Environment, How We Use and Control It, Allyn and Bacon, Boston, 1937.

OTHER REFERENCES USED

Experimental materials. Available for use and experiment by the pupils were a glass prism, a set of Prismacolor crayons, a series of brightly colored cards, 8 x 10 inches, to be tested in lights of various colors, and a whirling machine--together with 8-inch circular cards of all colors which could be arranged in any desired combination and then rotated to show addition of colors.

Figure 5. Whirling Machine

Presentation to the Class by Means of Natural-Color Photographic Slides

Color in our lives.

Slide #1. Title slide: Color In Our Lives.

Color is all around us. We see it; we use it; and we feel its effects, consciously or unconsciously. "Color has been an element of life since the creation; but the science of color as we know it today is comparatively young. There is much to be learned and much to be done about it."[1] With the present trend toward more color in

[1]Abbott, Arthur G., The Color of Life, McGraw-Hill Book Company, Inc., New York, 1947, Preface.

the home, the school, the hospital, industry, and life as a whole, it becomes advisable for us to learn to know and appreciate color so that we may derive more comfort and pleasure from the variety of hues which are constantly in our surroundings.

Slide #2. All the Spectrum Hues in Nature.

How frequently most of us have seen this familiar view of Mt. Chocorua! And yet have we stopped to notice the variety of colors which are combined to make up the picture? All the spectrum hues may be found. As we enjoy the colors, have we ever wondered why and how each color has come to be as it is in the scene? Enjoyment is most important, and may be enough for some; but for a richer experience and deeper feeling in the appreciation of the beauty before us we may need further knowledge of the scientific principles of light, vision and color, as well as the art of seeing. "Seeing consists of sensing, selecting, perceiving. Sensing is physical, selecting is mental, and perceiving is mental based on past experience."[1] Therefore, with this study, accompanied by the following group of slides and related experiments, it is aimed to give the pupils a broader experience which will enable them to perceive color with empathy, thereby enriching

---

[1]Huxley, Aldous, The Art of Seeing, Harper and Brothers, Publishers.

their lives.

How we see.

Slide #3. Fireworks.

Let us suppose that on the evening of July 4 we are watching a display of fireworks. If we close our eyes we still hear the booming and popping of the sky rockets, but we see nothing. In order to see, our eyes must be open so that light from the sky rocket can enter the eye and make an image upon the retina, the sensation of which will be carried to the brain by the optical nerve. The brain's interpretation of this stimulus is what we think we see. In this case, we have seen by light or energy waves which have come to the eye directly from the source of the light.

Slide #4. Danny Boy.

As we look at the little dog in this picture, how are we seeing? No source of light is evident. In this case, sunlight is being reflected from the dog and the green grass to our eyes. The nervous reactions of the retina, the optic nerve and the brain have again given us a mental interpretation of the stimulus. Here we have seen by reflected light, probably the most common method of seeing.

Boston University
School of Education
Library

Slide #5. Stained Glass Window.

When we view the stained glass window, we are seeing by transmitted light which has passed through the glass of the various colors. To summarize the scientific explanation of vision it might be stated that light must enter the eye and stimulate the retina to send a nervous impulse over the optical nerve to the brain where the impulse is interpreted. The light may come directly from the source or it may be reflected or transmitted. Here, a discussion would bring out other examples of these three types of seeing.

Light by which we see.

Slide #6. Diagram of Prism and Spectrum.

Next, let us learn something about the light by which we see. White light, as it comes to us from the sun, is made up of energy waves of various wave lengths and frequencies. If we pass a ray of sunlight through a prism, the different wave lengths are refracted, or bent, varying amounts so that the colors are separated. The shorter high-frequency violet waves are bent the most and appear at the top, while the longer low-frequency red waves are refracted least and appear at the bottom of the band of colors. Refraction of light waves might here be explained as the bending of waves as they pass from one medium to

another of different density. As will be noticed in the diagram, the rays are bent both upon entering and upon leaving the prism. The angle of incidence, or amount of bending, varies with the frequency.

Slide #7. Spectrum Colors.

This picture was made by photographing the spectrum colors which appeared on the wall when a ray of sunlight was passed through a prism, with the arrangement much like that of the diagram of the previous picture. The blue and violet do not show up as well as the other colors here because they could not be photographed accurately with the exposure adjusted to the amount of light reflected by the warm colors.

Slide #8. Electromagnetic Spectrum.

Visible light rays are those electromagnetic waves which stimulate the nerve endings of the eye so that they are interpreted by the brain as light or color. Actually, these visible light rays differ only in wave length and frequency from other electromagnetic waves with which we are familiar. From this diagram it will be seen that visible light comprises a very small area near the center of the electromagnetic spectrum. Waves of shorter length and higher frequency than those of visible light are ultraviolet, gamma rays, X-rays and Cosmic rays, while the

longer waves with lower frequency include infrared, radio waves and induction heating waves. Visible light waves, in structure, are like all of these other waves.

Slide #9. The Color Circle.

At the top of this picture may be seen the band of colors in the proportions in which they actually appear in the spectrum.[1] Careful examination will show the smallest area occupied by yellow. To 3 parts of yellow there are 4 of orange, 5 of red, 5½ of green, 6½ of violet and 8 of blue. The much larger area of cool colors may account for the fact that in some cases blue, indigo and violet are terms applied to the area here denoted as blue and violet. If this band of colors is turned into a circle, we have a color wheel in which complementary colors are found to be opposite each other. Such a color circle is frequently used in art and industry as an aid in determining color harmonies.

With this diagram still before us, we should also consider the intermediate colors. They are the colors which come between the spectrum hues and may be mixed by combining two neighboring spectrum colors in varying amounts. For example, in this chart there are two intermediate colors shown between the yellow and orange which

---

[1]Abbott, Arthur G., The Color of Life, McGraw-Hill Book Company, Inc., New York 1947, Page 102.

might be named yellow-orange and orange-yellow. In each division around this circle two intermediate colors may be seen but, actually, there are many intermediate colors between each pair of successive spectrum hues.

Slide #10. Hue, Value and Chroma.

How do we measure color? The dimensions of color are known as hue, value and chroma, all three of which are illustrated by this slide. Hue refers to color. The spectrum colors and their intermediates are all hues--such as red, green, blue, yellow-orange, blue-green and violet.

Value refers to the lightness or darkness of a color. In this case we have five values of blue. The lighter blues might have been carried still farther until white was reached, and the darker tones could have been extended to black. It should also be noticed that the first figure, illustrating hues, shows a variation in value, too, because yellow is lighter in value than the other colors.

Chroma means purity or intensity of color. Full chroma is that of a spectrum color. To reduce the chroma, pigment of the complementary color is added. In this case, orange is in full chroma at the left; and the successive stages to the right show the chroma reduced by adding blue, the complementary color. Other pairs of

complements are red and green, or yellow and violet. In art and industry, particularly in textiles and wall papers, reduced chroma is used to give more pleasing or subtle color harmonies.

When color is measured scientifically, it is defined numerically in terms of its hue, value and chroma.[1] A recent scientifically developed instrument is the spectrophotometer by which one can measure colors accurately in these three dimensions and distinguish several million variations of color tones. With the human eye we can distinguish differences among two million or more colors. However, we cannot name them all because at present our dictionaries list only about 3,400 words for colors and their tints or shades.[2] The spectrophotometer is used extensively in industry for the matching of colors in textiles and yarns.

Another scientific instrument used in relation to the study of color is the spectroscope, an optical device by which elements may be identified by the patterns of their dark line spectra. It is by means of this instrument that scientists have been able to determine the composition of the sun.

---

[1]Graves, Maitland, The Art of Color and Design, McGraw-Hill Book Company, Inc., New York, 1941.

[2]Abbott, Arthur G., The Color of Life, McGraw-Hill Book Company, Inc., New York, 1947, Page 141.

What color is.

Slide #11. Nasturtium Garden.

As we look at the red, orange and yellow nasturtiums among the green leaves in this picture, we may be impressed only with the colorful beauty of this little garden, or we may begin to wonder just what color is. Let us remember that in order to see this color the reflected light must enter our eyes and stimulate the nerve endings on the retina so that a nervous impulse passes over the optical nerve to the brain where an interpretation is made. But how do we perceive the separate colors? One theory put forth by scientists states that the nerve endings on the retina consist of rods and cones. The rods are sensitive to light and dark. In this case they help us to distinguish between the light and shade of the picture and they enable us to determine shape, which is so frequently defined by shadow. Rods are thought to be retractable, sinking into the retina when the light is strong and extending outwards to gather more light when the light is weak.

Cones, it is explained, are sensitive to color. We have three sets of cones, with one set sensitive to each of the three primary colors, red, yellow and blue. Red cones in our eyes are now being stimulated by the red

nasturtium, while the light from the yellow flowers stimulates yellow cones. In the area of the retina where falls the image of the green leaves, the yellow and blue cones are being stimulated to give the sensation of green. In the same way light from the orange nasturtiums stimulates the red and yellow cones to give a sensation of orange from that area in the retina. Therefore, we might define color as the sensation or interpretation by the brain of the stimulation of cones in the retina by light or energy waves of certain wave lengths and frequencies.

Color, like sound, is a vibratory phenomenon. Red, at one end of the spectrum, with longest waves of low frequency might be compared to a musical note of low tone, while violet at the other end of the spectrum with its short waves and high frequencies is more like the high, shrill tones in music.

Slide #12. Diagram of the Eye.[1]

This diagram shows the parts of the eye which are essential to vision. Light rays entering through the pupil are refracted slightly by the lens to bring them to a focus upon the retina where they stimulate the rods

[1]This blackboard diagram of the eye was drawn by G. Hartley Curtis, teacher of Biology in Winchester High School. The colors in the diagram are used for the purpose of stressing the different parts of the eye and of making more definite and lasting impressions in the minds of the pupils.

to give an impression of lightness, darkness or shape, and stimulate the cones to produce impressions of color. Among the energy waves which enter the eye, certain frequencies stimulate blue-sensitive cones, others the red-sensitive cones, while still others stimulate the yellow-sensitive cones. The brain's interpretation of all of these stimuli gives the total picture in color of what we see.

Color blindness.

Slide #13. Pseudo-Isochromatic Test for Color Perception.[1]

Color blindness is a deficiency in color vision which is common to about 4% of the men and .5% of women. Partially color-blind people may confuse only red and green while others may confuse more of the colors or may lack a sense of color. There is no known cure or treatment for color blindness; and one of the greatest difficulties is that color-blind people think they are seeing colors correctly, not realizing that they may be taking red for green or green for red. Such mistakes as this can be disastrous in many lines of work and therefore it is necessary to test for color blindness.

---

[1]The Pseudo-Isochromatic Test and test for color blindness were photographed with permission of the American Optical Company, Tremont Street, Boston, sole distributors of these tests.

One type of test used is this series of Pseudo-Isochromatic plates on which there may be large numbers or definite patterns which are clear to the person with normal color vision but cannot be seen by the color blind.

Slide #14. Holmgren Test for Color Blindness.

Still another type of test for color blindness is the Holmgren Test in which small tufts of yarn must be sorted and placed in two piles, those nearest in color to the red of C and those nearest to the green of A. At this point it is interesting for pupils to discuss and list the occupations in which accurate color vision is essential.

Addition and subtraction of colors.

Slide #15. Colors on the Whirling Machine.

Colors are said to be added when lights of different colors are mixed. Here we see red, yellow, green and blue discs arranged on the whirling machine. Since each colored section is seen by reflected light, it necessarily follows that light of each of these four colors is being reflected.

Slide #16. Whirling Machine in Motion.

If we put these colors into rotation, the reflected colored lights will blend giving us, in this case, an effect which is near to white. It is well at this time

to allow pupils to select their own color combinations and experiment with them on the whirling machine in order to see the results of various color additions.

Slides #17, 18 and 19. Colored Cellophane.

These next three slides may be used to show both addition and subtraction of colors. In order to experiment with addition it is necessary to use three projectors of equal power or place the slides in front of three flashlights. The following color combinations may be obtained.

1. The red slide produces red on the screen.
2. The green slide produces green on the screen.
3. The blue slide produces blue on the screen.
4. Red and green slides produce yellow on the screen.
5. Blue and green slides produce blue-green on the screen.
6. Red and blue slides produce purple on the screen.
7. Red, green and blue slides projected simultaneously to the same spot produce white on the screen.

Red, green and blue are said to be primary colors in light because added together they produce white light.

Subtraction of colors may also be explained by means of these slides. When the red slide causes the screen to appear red, it is because red light is being transmitted by the slide, while the green light coming from the same source is being subtracted or absorbed by the pigment in the slide. In the same way the green slide

transmits green and absorbs or subtracts red while the blue slide is transmitting blue light only. If the red and green, or all three of these slides, are placed in the projector at once, the screen appears black because the group of slides are subtracting all colors and no light is transmitted to the screen.

Still further experiment is of interest also. Using the projector as a spot light, study the subtractive effects of each color when the colored lights fall upon faces, colored cardboard, or the colors of pupils' clothing. For example, in the red light a bright green skirt will appear black, while in the green light a bright red sweater would also lose all color. Addition and subtraction of colors is exceedingly important when colored flood or spot lights are used in producing desired stage effects.

Slide #20. Primary, Secondary and Tertiary Colors.

The study of subtraction of colors continues when we study paints or pigments. In fact, whenever color is seen by reflected light, subtraction of some of the white light has taken place and we see only the reflected colors. It seems a bit hard to realize that a red skirt is red because it is absorbing green light and reflecting only the red. Of course it appears to be

the color of the light which comes to our eyes.

It has been mentioned that primary colors in light are those which add up to white light and, by experiment, we have found them to be red, green and blue. In pigments, primary colors are those which cannot be produced by mixing two other colors. Red, yellow and blue are primary colors in pigments. They are the first or primary colors from which, by mixing any two of them, we may obtain three other colors known as secondary colors. They are orange, green and purple. If the three primaries are mixed together, brown, a tertiary color, is obtained. The three primaries and three secondary colors constitute the six hues of the spectrum. Colors in between the spectrum hues, and obtained by mixing any two neighboring colors, are known as intermediate colors, as was explained when studying slide #9 which shows the color circle.

Pupils should be given an opportunity to experiment with the addition of colored lights as well as with the subtractive processes of mixing pigments.

Further experiments with color.

Slide #21. Campfire.

Just as this flame seems to be advancing out of the darkness and extending to us a feeling of warmth, so do

the colors of the flame seem to have similar effects at all times. Red, orange and yellow are known as advancing colors because they seem to be nearer to us than the other colors. Also, they are called warm colors because of the feeling of warmth imparted by them. This is not due solely to the fact that we associate them with fire because very accurate scientific measurement shows that they actually do produce temperatures slightly higher than those of the cooler hues.

Slide #22. Snow Ghosts.

In contrast to the warmth of flame colors we find the coolness of the blue and near-blue tones which are associated with snow and ice. These colors with blue predominating are known as cool colors and are also called receding colors because of their tendency to pass into the background.

In home decoration these cooler colors are more frequently used in the warm sunny rooms, while the warmer colors tend to provide a feeling of warmth for those cooler rooms which lack sunshine.

Slide #23. Vibrating Colors.

Another phenomenon in the study of color is that of vibration or rapid motion to and fro when two complementary colors of strong chroma are placed side by side.

In this picture a slight vibration may be seen along the dividing line, and if the bi-colored disc is slowly rotated the colors do not blend but give an interesting pattern of vibration between the red and green. Rapid rotation, however, will cause them to blend into gray. Other complementary colors do seem to vibrate, but the effect is most noticeable with the red and green.

One more experiment with color which is difficult to illustrate photographically, but is very much worth trying, is that of the after-image. Against a brilliant blue background place an orange moon, or other figure. Instruct the pupils to stare at it for half a minute. Quickly replace the colors with a white cardboard. The students will exclaim as they see a blue moon against the orange background. The explanation is that on the part of the retina receiving the stimulation from the blue background the blue cones are fatigued. The white should stimulate all cones, but since the blue are fatigued they do not respond as readily and the red and yellow cones give the sensation of orange. Of course the same is true in regard to the cones which originally were stimulated by the orange moon. Later they are fatigued and the blue cones record a blue moon. This principle explains the fact that any time when we stare

at a strong well-lighted color and then look away we may see the same shape in a complementary color. This phenomenon is known as after-image.

Symbolism, significance and emotional effects of color.

Slide #24. Poinsettia.

It is generally recognized by scientists, as well as artists, that color makes its impression upon us. "Color can affect personality and mental outlook as definitely as can a sleepless night. An intellectual response comes from an understanding of the forces at work and may range from great pleasure through disgust. With or without understanding, color usually effects an emotional response."[1] Therefore, let us now make a study of the feelings aroused by color as well as the symbolism and significance of the various colors appearing in our surroundings. Wassily Kandinsky,[2] Arthur G. Abbott and others, after giving the matter considerable thought, have brought out many interesting and helpful ideas. Kandinsky has gone so far as to have drawn the parallels between color tones and the sound harmonies from the various musical instruments.

---

[1]Abbott, Arthur G., The Color of Life, McGraw-Hill Book Company, Inc. 1947.

[2]Kandinsky, Wassily, On the Spiritual in Art, Solomon R. Greggenheim Foundation, New York, 1946, Hilla Rebay, Editor.

Let this poinsettia remind us of red and we immediately have the association of red with Christmas. Red also warns us of danger and means "stop" in our signal lights. Psychologically red is a typically warm color. It has a vivid restless appeal, arousing a feeling of strength, energy, ambition, courage, determination, joy, triumph and love.

Slide #25. Vermont Countryside.

Color associations become fixed in our minds as we see a color used frequently for any given purpose. This pastoral scene from a Vermont hillside gives us an example of a typical use of red paint.

Slide #26. Orange Zinnias.

Orange carries the warmth of the flame, is advancing, and seems to emanate health and cheer.

Slide #27. Golden Wedding Cake.

Yellow is warm, advancing and stimulating. It may signify caution or a person of low character as "a yellow dog." Gold or yellow symbolizes 50 years; and in this picture we see the yellow napkins and golden decorations on the cake prepared for a fiftieth wedding anniversary. For a twenty-fifth anniversary silver would be used.

Slide #28. Green of the Pine.

As we look into the soft green of these pine needles it is easy to experience a sense of quiet restfulness. Green is a cool placid color, and when tending toward the blue becomes receding. It may symbolize envy or safety. Because of its calm, quieting effect upon us the extensive amount of green in nature is accepted with little thought or feeling, other than a sense of complete ease and comfort.

Slide #29. Blue of the Sea and Sky.

Just as this view of the sky and water is cooling and restful, so we find the color blue to be cool, soothing, serious, profound and retreating. Typically heavenly in its color it symbolizes truth, wisdom, eternity, immortality, constancy and loyalty. Blue also refers to a feeling of despondency.

Slide #30. Orchid.

Purple is the color of royalty, mystery, mourning and grief. In its softer tones, like those of this orchid, it seems to symbolize frailty and old age. It is subduing, cool and receding.

Slide #31. The Bride.

The white of the bridal gown symbolizes joy, purity and innocence, while in our churches white is used to

represent divine power and light.

Black, the opposite of white, is the robe of deepest sorrow and final silence.

Brown and gray are used by the Quakers for simplicity, and gray may also arouse a feeling of desolation.

These few brief statements are not adequate to express the meanings they imply because "variations of color, like those of music, are of a most subtle nature, and awaken in the soul much finer vibrations than words can describe."[1]

Slide #32. Our Flag.

We are all stirred with a feeling of pride and patriotism when we see the colors of our national banner as it floats on the breeze. Here we find the red symbolizing hardiness and valor as well as the blood shed for freedom. The white stands for purity and innocence while the blue symbolizes vigilance, perseverance, loyalty and justice.

Doctors and psychiatrists realize the therapeutic values of color to such an extent that some are treating nervous disorders with color. Green is known to be emotionally soothing. Blue raises the blood pressure, is antiseptic and tonic in effect and is more soothing

---

[1]Kandinsky, Wassily, On the Spiritual in Art, Solomon R. Greggenheim Foundation, New York, 1946, Hilla Rebay, Editor.

than green. Orange is an emotional stimulant, promoting a sense of well-being and cheerfulness. Yellow is a mental stimulant, useful in cases of mental deficiency. It is also used in long continued doses for tubercular cases. Red is a mental stimulant used in adjusting cases of melancholia. Violet acts upon the heart, lungs and blood vessels, increasing the resistance of the tissues. It is thought that color can have its good effects if it is applied correctly. However, effective treatment of any disorder by color is a complex science involving considerable knowledge of the patient as well as the power of color.[1]

Color in nature.

Slide #33. Winter Sunrise.

Pictures have been painted and poems written portraying the beauty of a sunrise or sunset. But how do scientists explain these colors? When the sun is near the horizon, as it was in the early morning for this picture, its light comes to us diagonally through the atmosphere. Therefore, it meets with a larger amount of interfering material, in the form of moisture and dust, than it does when the sun is directly overhead. This interfering matter absorbs some light and passes

---

[1] Abbott, Arthur G., The Color of Life, McGraw-Hill Book Company, Inc. 1947

on the light of other colors. Thus, as the moisture conditions and dust content of the air vary from time to time, the patterns of colors in the sunrise will be greatly changed. Over an expanse of water the sunrise colors are duplicated by reflection.

Slide #34. A Cold Sunset.

In contrast to the reflection of sunrise colors in the last picture, we have here the lacy network of trees silhouetted against a cold November sunset. The explanation of colors is the same as for the sunrise, but one could go on indefinitely showing pictures of the various patterns of color.

Slide #35. Rainbow.

How we all love to see that infrequent, and fleeting, bit of color known as a rainbow! We are all familiar, too, with the conditions necessary to produce a rainbow.. With the sun shining from low in the sky into the rain of a shower, the light may be refracted and reflected within each drop in such a way as to separate the spectrum colors and project them upon the clouds and hillsides in the form of an arc. The primary rainbow, most frequently seen, is caused by a single reflection within each raindrop and has the red at the top, while the violet light reaches the eye from the inside of the

curved band of colors. Occasionally, under favorable conditions, it is possible to see a secondary larger rainbow in which the order of colors is reversed. This comes from raindrops higher in the sky and is caused by a double reflection from the raindrop.

Slide #36. Early Azalea.

In the early springtime it is always a joy to come upon the brilliant beauty of the azalea and other spring flowers. "Where do they get their color?" we might ask. These bright petals contain pigment, a chemical substance, produced within the plant, which absorbs some light and reflects the rest, thus giving the color effect we see.

Slide #37. Turk's-Cap Lilies.

Here again the coloring of the blossoms, this time yellow, is due to pigment found within the plant, while the green of the foliage is due to a substance called chlorophyll. It may be defined as a chemical substance, or pigment, which is produced within the plant. Chlorophyll always appears green and is most important in the life of plants and animals for the part it plays in the process known as photosynthesis, or food making in plants. In the presence of sunlight and chlorophyll the plants use carbon dioxide from the air and water obtained through the roots to make the starches which build up the various

parts of the plants. Animals, including ourselves, are dependent upon these starches for food and so are indirectly dependent upon chlorophyll. A few plants like Indian pipes, mushrooms and dodder have no chlorophyll. In this case they are not manufacturing their own food but are living on food from other plants. Indian pipes and mushrooms are saprophytes, living on decaying plant life, while the dodder is a parasite which obtains its food from living plants, thereby killing its host.

Slide #38. Fall Foliage.

How is it that the leaves which have been so green all summer can quickly change to their brilliant fall colors? One theory brought forth by scientists is that the brilliantly colored pigments, formed by the plants themselves, are in the leaves all summer but are hidden by the intense green of the chlorophyll. In the fall when the food-making process slows down and the chlorophyll is decomposed, the other colors come into view. For a short time we may enjoy their brilliance and then they, too, decompose in the air and rain and leave the ground carpeted with the soft brown leaves, the brown being due to a pigment called melanin.

Slide #39. Promethea Moth Caterpillar.

Protective coloration is very prevalent in nature;

and here we see one example of it when we have to look so carefully to find the green caterpillar which is feeding upon the leaves of the apple tree. In the caterpillar stage any insect is a great feeder. Therefore, protective coloration at that time increases greatly his chances of living to maturity. In the adult stage, when feeding is not important, this promethea or silk-worm moth acquires a much more showy color pattern.

It would be well for students to look for pictures of birds, animals and insects whose colors blend with those in their backgrounds. It is possible to compile a long list of interesting cases of protective coloration.

Slide #40. Nest and Young of Oven Bird.

Have you ever sought out the nest of the oven bird? Just once in many years of search and observation has the author ever found one. Here it is; and you will notice how carefully you have to look to see the protectively colored babies in their domed-over nest built among the brown leaves on the ground. Similar provision for protection of the young by coloration is found many times over in the study of wild life.

While we are speaking of birds it might be well to mention the more brilliant colors to be found among many of the adults. The color in birds' feathers may be due to pigments, but frequently it is caused by iridescence.

For example, much of the blue of the brilliantly colored blue jay is not pigment but is due to a structure of the feathers which causes refraction of light rays in such a way that we see blue. This accounts for the fact that the coloring seems to change as the bird moves from one position to another. Iridescence might here be defined as the appearance of color where no pigment is present. This opalescent color is the result of refraction, absorption and interference of the light rays caused by the structure of the surface. Examples of iridescence are the colors in soap bubbles, oil or water films, sea shells, ceramic glazes and the feathers of birds.

Slide #41. Spacious Skies.

What makes the sky and water so blue when we know that both are colorless? Scientists explain that the blueness of the sky is due to absorption and diffusion of light by particles of moisture and other matter in the air. Blue is the color most extensively diffused.

The water of a lake or ocean reflects in a darker tone the color of the sky; or, the water may be colored by matter which is within it. The white clouds are made of condensed moisture which is reflecting all light. The breakers on the waves have so much air in them that they too reflect all light and appear white.

Slide #42. The Storm.

Cloud effects are fascinating to study, not only for themselves but for the play of colors they effect upon the open fields as they move across the sky.

Reproduction of colored pictures.

Slide #43. Colored Pictures.

To-day we tend to take for granted the many colored pictures and advertisements we see in the magazines. The lithographing process by which these have been produced has, in years past, undergone much scientific study and experimentation. Now the process has been so improved and perfected that beautiful colored pictures with intricate effects can be produced in large quantities quite inexpensively.

The picture of the horse shown at the lower right was printed by the three-plate printing process. First, the original painting had to be photographed through filters, one to select the yellows from the picture, one to select the reds and a third to select the blues. Then from these three photographs three plates were made, one for the printing of each of these three primary colors. First the yellow print is made. The red print over that will give us red, orange and yellow in the picture. Then a blue print superimposed over the first two will produce

the other colors since blue over yellow gives green; blue over red gives purple; and the blue over red and yellow produces the brown which predominates in this picture. This three-plate printing process is used extensively for the type of colored pictures we find on calendars and in magazines.

Color photography.

Slide #44. Nest and Eggs of Hermit Thrush.

Natural color photography has been developed within the last two decades and now has been perfected to the point where it is a very satisfactory process, although still considerably more expensive than black and white photography. It seems little short of miraculous to realize that with the click of the shutter, giving perhaps 1/50 or 1/100 of a second exposure, the entire picture is recorded in natural colors on the film. Just how can this be done? Kodachrome and Ansco color films have in the emulsion three sensitive layers. The top layer is sensitive to blue light, the second to green light and the third layer is sensitive to red light. Exposure in the usual manner forms pictures in each of the three layers. An involved and delicate process of development produces a negative. Next, by a special chemical process, the negative is changed to a positive. The film is then

stained, the top layer yellow, the second, magenta and the third a blue-green. When viewed by transmitted light from a white source the dyes absorb light of their own colors and transmit blue, green and red, thus forming a picture with approximately the same coloring as the original object.

What are some of the advantages of color photography? They are many and varied. Therefore, only a few will be mentioned and illustrated here.

This picture of the nest of the hermit thrush is an example of capturing for permanent reference and enjoyment a view which could have been but a memory after the first few moments. A picture like this makes it possible to share the beauty and enjoyment as well as the scientific facts with others.

Slide #45. Sun Star.

This huge sun starfish is not commonly seen, but the author had an opportunity to make this photograph when the starfish was brought into Audubon Nature Camp, Muscongus Bay, Maine, by a lobster fisherman who had discovered it in one of his traps. To tell about it is one thing, but to be able to show a colored picture of it as one speaks about handling and observing it can make a much more interesting and lasting impression on the

listeners. By means of color photography many things may be brought into the class room which cannot otherwise be there.

Slide #46. Grandfather.

In the school camera clubs we study the taking of portraits as well as other pictures. Studies in color can make exceedingly interesting and lifelike portraits as in this case where Grandfather seems to be quite at ease among his books.

Slide #47. Little Ellen.

And now we see little Ellen who, as usual, is ready for some fun!

Harmonizing colors.

Slide #48. Color Harmonies.

A composition in color, whether it be a furnished and decorated room, a costume, a design or a painting must follow the general elements of art. The composition is harmonious when it observes and follows nature's color practices and has unity, balance and fitness.

The color combinations in this picture represent some of the color harmonies most commonly used. The three at the left are known as complementary harmonies because the two colors in each figure are found directly across from each other in the color wheel. The middle vertical row shows pairs of analagous or neighboring

colors, while the rectangles at the right give examples of monochromatic harmonies in which varying tints and shades of one color are used. There are names applied to still other color harmonies, but these seem to be sufficient for this study.

Slide #49. Complementary Color Harmony, Poinsettia.

In the poinsettia we have an interesting example of the complementary harmony. Neither color is pure chroma, but slightly grayed, thereby presenting a more pleasing combination of colors.

Slide #50. Analagous Color Harmony: Barberry Blossoms.

These bell-like blossoms of the wild barberry make not only an attractive bouquet or picture, but at the same time they are illustrating for us an analagous color harmony.

Slide #51. Dominant Color Harmony: November Bouquet.

From the early season blooms of the barberry, we now go to a November bouquet for an example of monochromatic harmony. If we look carefully at the many greens of the picture, including several on the vase, the light and shade of the softly draped background, the deep green leaves and the soft greenish tint in the Easter lily, we have an excellent example of monochromatic color

harmony. However, in this picture the harmony dominated by green has been broken by touches or accents of the complementary color. Frequently we use such color harmonies as this in decorating our homes.

In case you are interested in the bouquet, it is a fact that these flowers of all seasons--weigelia, Easter lily, hollyhocks, asters and chrysanthemums--were all picked in the same garden on November 1, 1947.

Media of expression in color.

Slide #52. Colors for a Hooked Rug.

When one speaks of artistic color composition one's first thought may be in terms of pictures or designs executed in oil paints, tempera paints, water colors, finger paints, crayons, pastels, or any other medium frequently used by artists. But there are many more media in which we may, and do, express ourselves and our feelings colorfully. Only a few of the hundreds of possibilities will be illustrated here. In this picture we see bundles or skeins of narrow strips of cloth ready to be hooked into this rug. Notice that there are several tints and shades of each color. At the bottom of the picture you may see how the tints of orchid have been worked into the scroll.

Slide #53. 9' x 12' Hooked Rug.

Here again we see color and design as hooked into this 9' x 12' living room rug. Many other crafts, with which we occupy our leisure time and satisfy our urge to create and express, are continuously causing us to study compositions in color. Whether we knit, paint, sew, hook, decorate our rooms or select our clothing, we are expressing ourselves in color.

Slide #54. McArthur Garden.

Even the gardner who spends so much of his time working the soft brown earth thinks in terms of color, delicate subtle color harmonies and compositions. This garden, portraying General McArthur, was photographed in the Boston Public Garden during the war.

Slide #55. Detail of McArthur Garden.

A closer view of part of the garden shows how the detail was obtained entirely by tiny plants of different colors.

Pupils should discuss, list and bring in as many examples as possible of the different media with which we may express ourselves in color.

Conclusion: Uses of color in our lives.

Slide #56. Interior.

The uses of color are so many and varied that we

cannot begin to consider them all in this study. Therefore, only a few will be illustrated and the suggestion offered that all who are interested continue the thinking and observation for themselves. This picture is just one of hundreds which might be shown to illustrate the decoration of homes with pleasing, artistic and comfortable color combinations. Carefully planned lighting effects may enhance the composition.

Slide #57. Party Gowns.

When designing or selecting party gowns, color is chosen for its beauty, fitness to the occasion and harmony with the complexion of the person wearing it. In fact, all clothing should be planned with these same general principles in mind. Men, as well as women, wear carefully planned and executed color harmonies.

We have studied color from many angles. We are color conscious when selecting our clothing, decorating our homes, working at crafts, composing or selecting pictures, and even in buying our foods and other necessary materials. Color has found its place in industry. Even in our churches we find deep, rich color harmonies, but in our schools we still find more drab, dull paint than in any other place where people are living and working. Why is this so? Why shouldn't we consider the

psychological effects of color and put a few ideas into practice in order to make the school life of the child a more colorful experience?

Slide #58. Color in our Schools.

Some communities are experimenting with color in their schools. In Winchester, Massachusetts, we may enter the Lincoln School to be greeted by this display of colors in what would otherwise be a long, dark corridor. The children tell us they are very fond of the new colors in their school.

Slide #59. A Colorful Classroom.

Entering the kindergarten room of the same school, we find the colors planned to delight the children, as well as to provide most effective lighting and most harmonious working conditions for them. A tour of this elementary building shows a pleasing variety of color harmonies in the different class rooms. The colors for the entire building were planned scientifically, with due consideration for natural light and exposure, by Professor Gyorgy Kepis of Massachusetts Institute of Technology, with the approval of Dr. Forbes H. Norris, Superintendent of Schools, and Dr. Mildred Landis, Art Consultant in the Winchester School Department. Citizens of the town and school officials are sufficiently pleased

and satisfied with results to plan to use color in each of the other buildings as they need renovating.

Slide #60. Twilight Colors.

From the first ray of light which comes with the dawn to the last gleam of light in the evening, each day of our lives is filled with color. Even as we sit around the evening campfire we watch the delicate changing hues of the sunset (fade out the picture by slowly closing fingers over the lens of the projector) as they fade and disappear until only the campfire is left, advancing from the darkness to warm and cheer us. Eventually the light of the fire fades, too, and disappears leaving us in darkness--with no light and no color, until the dawning of the next day brings to us again all of the Color In Our Lives.

CHAPTER III

EVALUATION OF THE STUDY OF COLOR

Results of Objective Testing

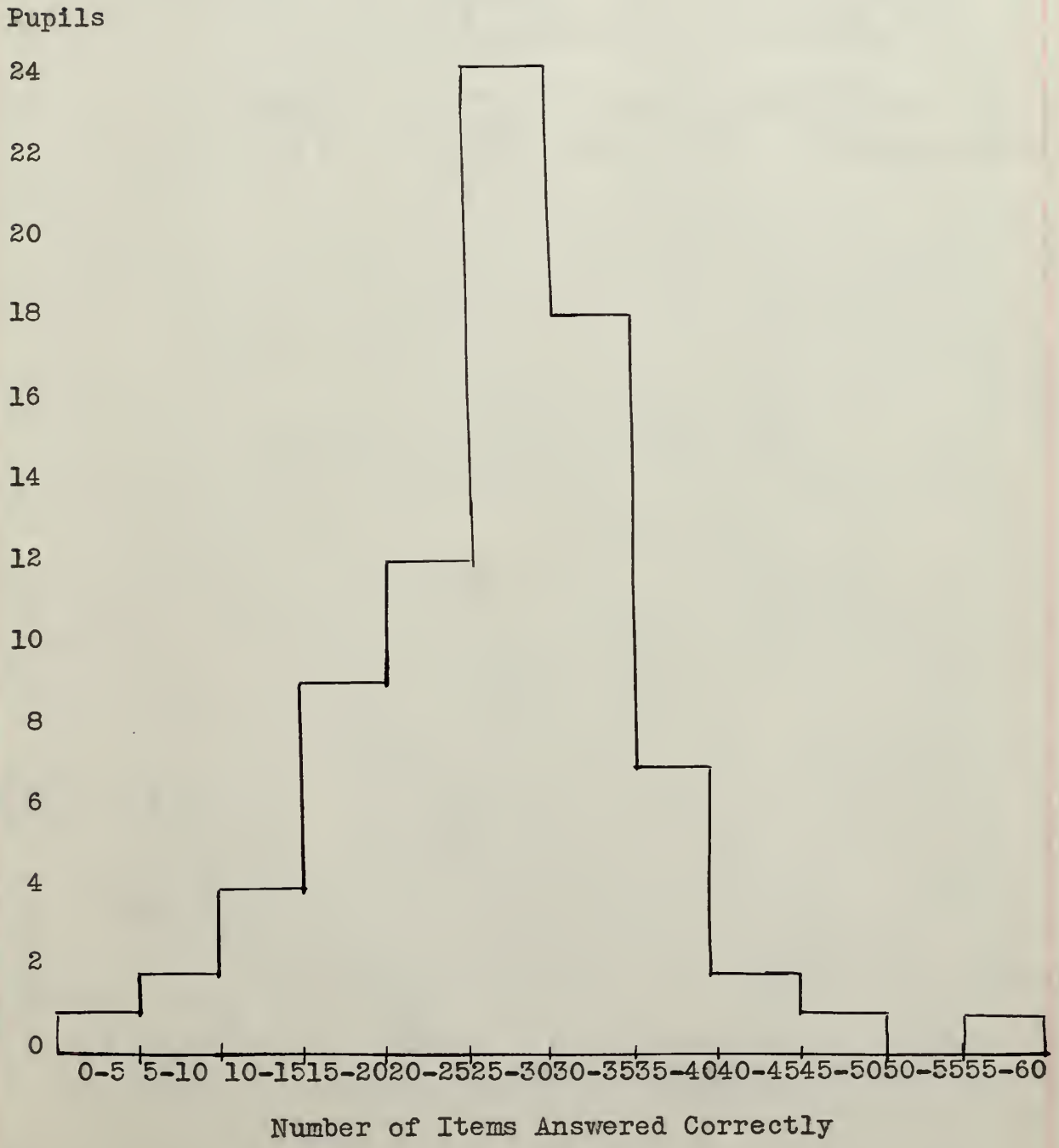
Pretest. The test of one hundred items, shown on pages 33 to 39 , was given as a pretest to determine the students' previous knowledge of color. The results, as recorded in Table 5, show the median to be approximately 28 items correct, while the scores vary from 4 to 57, indicating considerable lack of knowledge in this area with an opportunity for a relatively large amount of learning.

Table 5. Distribution of Science Pupils According to Number of Correct Responses on the Pretest on Color.

Correct Responses	Boys	Girls	Total
0 - 5	1	0	1
6 - 10	2	0	2
11 - 15	3	1	4
16 - 20	6	3	9
21 - 25	5	7	12
26 - 30	14	10	24
31 - 35	6	12	18
36 - 40	4	4	8
41 - 45	0	2	2
46 - 50	1	0	1
51 - 55	0	0	0
56 - 60	1	0	1
Totals	43	39	82

Final test. Three weeks later, after teaching the topic, Color In Our Lives, with the aid of natural color

Figure 6. Distribution of 82 Science Pupils According to Results of Pretest on Color



photographic slides, the same test was given again as a final examination on the subject. In this case the median was 63 with scores extending over a range of 9 to 94

Table 6. Distribution of Science Pupils According to Number of Correct Responses on the Final Test on Color

Correct Responses	Boys	Girls	Total
11 - 15	1	0	1
26 - 30	1	0	1
31 - 35	1	1	2
36 - 40	3	2	5
41 - 45	2	1	3
46 - 50	5	2	7
51 - 55	4	2	6
56 - 60	2	5	7
61 - 65	5	5	10
66 - 70	6	6	12
71 - 75	4	5	9
76 - 80	3	3	6
81 - 85	1	1	2
86 - 90	3	4	7
91 - 95	2	2	4
Totals	43	39	82

Growth. A comparison of test results for each individual shows the growth within the area for each student. These are recorded in Table 7 where it will be seen that the median is 39, and the growth scores range from 4 to 69.

Figure 7. Distribution of 82 Science Pupils on Final Test on Color

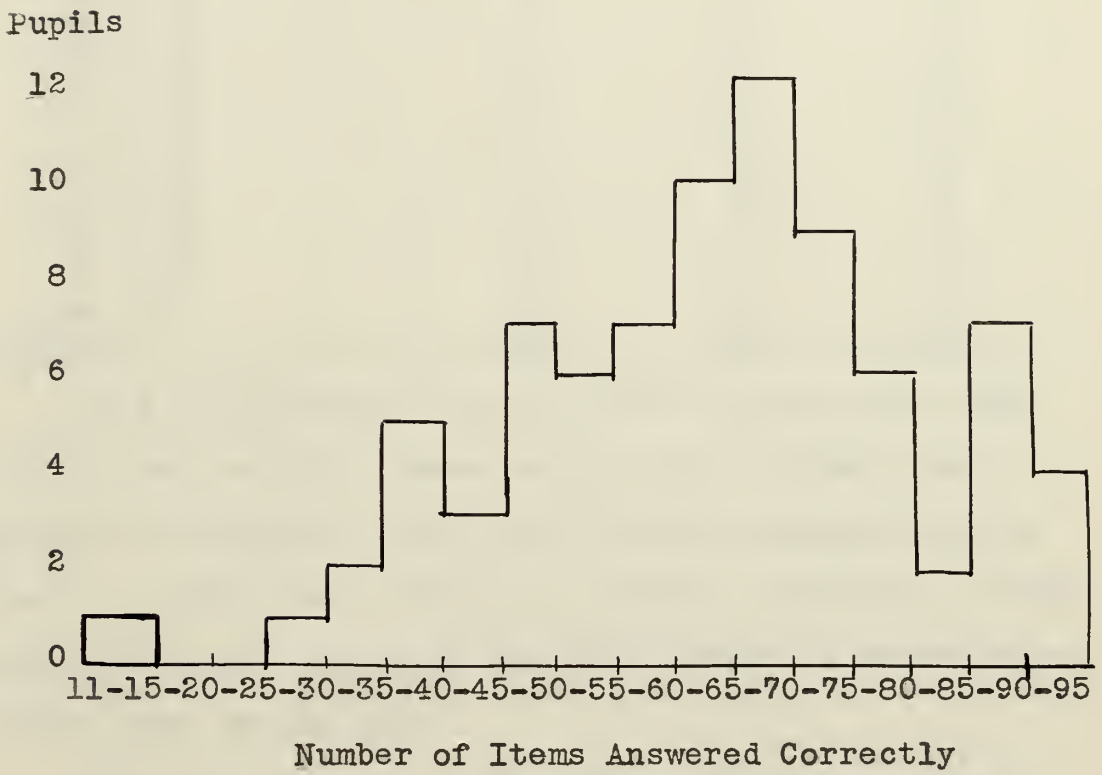


Table 7. Distribution of Science Pupils According to Growth, Based on Increase in Correct Responses from Pretest to Final Test.

Increase in Correct Responses	Boys	Girls	Total
0 - 5	1	0	1
11 - 15	3	1	4
16 - 20	0	1	1
21 - 25	4	3	7
26 - 30	2	5	7
31 - 35	9	6	15
36 - 40	8	5	13
41 - 45	9	6	15
46 - 50	1	5	6
51 - 55	2	4	6
56 - 60	2	1	3
61 - 65	1	1	2
66 - 70	1	1	2
Totals	43	39	82

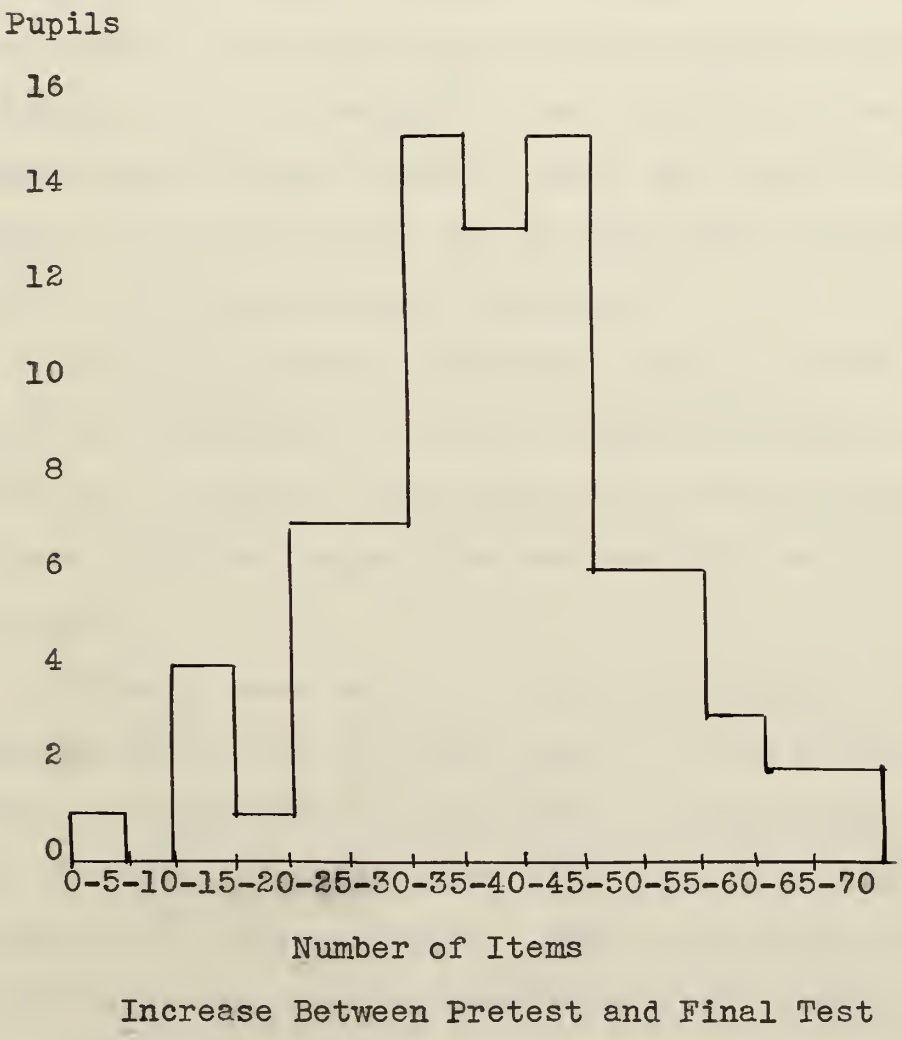
It is interesting also to note at this point that the boy who had the lowest score on the pretest made a growth of 55 points, while the boy who accomplished the least in growth was one who was absent during most of the study in color. In fact, the four lowest in growth were absent part of the time.

The median growth of 39 points and maximum growth of 66 points indicate that learning is an important part of the activity when interest is increased to the extent that conceptions are made clearer by the use of natural color slides.

Constructive Comments

Pupil reactions. Most of the students seem to have

Figure 8. Distribution of 82 Science Pupils According to Growth Within the Area, as Determined by Pretest and Final Test



thoroughly enjoyed the study of color. On the day of the pretest, several returned after school to inquire about the work which lay ahead. Throughout the time of study there were interesting comments every day by individuals who had discovered some idea which appealed to them as new and interesting. Others had noticed for the first time colors or designs which they had passed by on many occasions, like the mosaic at the entrance to the Library. Knowing their pretest results, many were anxious to do better on the final test and to know their own growth in terms of additional correct responses.

The pupils seemed to be particularly pleased with the colorful illustration of the photographic slides. The privilege of going to the projection room to view these pictures inspired cooperation and courtesy on the part of the pupils.

Notebooks were kept by the pupils throughout the study in which they recorded answers to the Problems for Study and completed the Dictionary of Color Terms. They were encouraged to experiment with color addition, subtraction and color harmonies. When it came time to pass in the notebooks, some of them were proudly and fondly placed on the teacher's desk. The wide variety of colorful cover designs and the originality of color experiences

recorded within bear witness to the fact that the pupils found much enjoyment in their work.

Suggestions for improvement. As usual, when a piece of work progresses, there are occasions when it is possible to see opportunities for improvement. Some of these are listed below.

1. The projection room could be made darker if traverse curtains of denim were placed over the half windows.
2. The wall screen, available in the school, could be improved by painting it flat white instead of leaving it with the aluminum finish.
3. A short extension cord could be attached to an overhead light instead of using the wall outlet with a cord going half way across the room.
4. The test should be revised with substitutions for the few items which were most frequently misunderstood, the two or three where controversy arose, and the three which proved to have two possible answers.
5. More time for the study would be helpful when working with freshmen.
6. The topic could be presented to, and would probably be more easily understood by, Physics classes made up of juniors and seniors.

Looking Ahead.

Future outlook. The work, as planned for this study of color, has proven interesting to pupils and teacher and has brought about satisfactory results. Therefore, a similar study will be conducted in essentially the same manner for the science classes next year. The series of 60 natural color photographic slides will be filed as a unit ready for future reference. The next step will now be to select another topic from the science outline for special study and illustration by means of colored slides.

Further research. Teaching, supplemented by color photography, can be just as effectively applied in other fields of education and at all grade levels, especially in those activities where visual aids are desired. For the teacher who owns a camera, using 35 mm. film, there are extensive opportunities for taking pictures which are related to the school work. Some may be taken of student activities within the school, while many more may be brought in from the outside to supplement the books and materials provided in school.

The following suggestions will show a few of the possibilities for other curriculum-building plans which could be similarly illustrated to great advantage. House-hold Arts classes might continue this study of Color In

Our Lives with work on color harmonies in our homes or colors in our clothing. A boys' Physics class might consider color harmonies in men's clothing or an historical sketch of color harmonies in men's clothing. Commercial department students might make a special study of color in advertising, packaging or industry. Art classes could investigate methods of reproducing colored pictures and media of expression in color. Chemistry students would be fascinated by a photographic study of significant colors and color reactions in Chemistry.

If we leave the topic of color and consider science in general throughout all grades, we might list such photographic studies as a trip to the zoo, life in the aquarium, marine life of the tide pools and beaches, birds and their babies, pets, wild flower neighbors, nature legends, ferns of our community, herbs and their uses, domestic animals, lumbering, paper making, road building, safety devices in our homes, our national parks, and many many more. These few topics are merely suggestive of an endless list which could be compiled and upon which a small army of photographers might go to work in order to prepare the photographic slides for use in teaching.

Conclusion. Through this study of Color In Our Lives the teacher has had a better opportunity to become

acquainted with the individual pupils. Through the use of the photographs, taken by the teacher, many interesting questions arose and, as a result of discussions inspired by the pictures, both teacher and pupils came to know each other more closely.

From this experience it is easy to conclude that natural color photographic slides are an effective aid in teaching. They are especially valuable when a teacher is inspired by his or her own enthusiasm to make the photographs which are most adaptable for motivation of the study.

APPENDICES

Appendix A
General Purpose Table - Boys

Boys	Chron. Age	I. Q. Non Lang.	I. Q. Lang.	I. Q. Tot.	English Test A Score	English Test A %ile	English Test B Score	English Test B %ile	Color Pre-Test	Color Fin. Test	Color Gro wth
1.	14- 2	105	100	102	28	10	33	20	25	56	31
2.	14- 6	91	102	98	35	53	48	82	33	62	29
3.	15- 3	148	81	99	32	35	40	60	20	57	37
4.	15- 3	112	83	90	29	20	31	10	21	45	24
5.	13- 6	146	109	117	33	40	47	80	32	42	10
6.	14-11	151	96	107	34	50	39	55	23	76	53
7.	14- 5	89	103	98	33	40	30	9	19	60	41
8.	14-10	118	94	99	34	50	39	55	29	67	38
9.	16- 1	92	98	97	31	30	34	25	27	67	40
10.	15- 8	118	64	82	27	7	36	35	29	62	33
11.	16- 9	97	70	71	29	20	39	55	36	66	30
12.	15- 9	105	110	110	32	35	37	40	18	84	66
13.	16- 0	114	67	83	27	7	32	15	2	8	6
14.	14-10	119	112	115	35	53	40	60	33	88	55
15.	15- 3	84	107	101	28	10	32	15	28	71	43
16.	14- 5	125	106	110	33	40	36	35	36	85	49
17.	14-11	133	113	118	31	30	38	50	33	69	36
18.	14- 9	84	98	93	23	1	33	20	15	53	38
19.	13-11	143	111	117	30	25	34	25	27	40	33
20.	14- 3	123	97	101	31	30	38	50	38	72	34
21.	13- 7	104	102	103	43	75	37	40	29	69	40
22.	14-10	89	97	95	30	25	34	25	28	61	33
23.	14- 8	113	133	128	49	90	42	65	46	86	40
24.	17- 1	96	64	76	26	4	28	7	13	33	20
25.	13- 8	180	125	135	36	56	34	25	31	73	42
26.	15- 6	117	64	83	27	7	15	1	25	75	50
27.	14-11	94	106	101	27	7	29	8	25	37	12
28.	14- 9	137	117	123	33	40	37	40	24	54	30
29.	14- 1	166	115	126	32	35	43	67	29	93	64
30.	14- 5	103	117	115	41	70	40	60	27	65	38
31.	15-10	111	90	94	31	30	40	60	27	47	40
32.	16- 7	90	106	102	30	25	37	40	28	48	20
33.	14- 3	105	99	100	30	25	36	35	35	77	42
34.	14-11	135	89	101	30	25	32	15	30	73	43
35.	15- 5	60	85	72	29	20	32	15	22	26	4
36.	15- 6	84	104	100	29	20	43	67	17	51	34
37.	14-10	158	135	145	39	66	53	92	57	94	37
38.	15- 3	88	84	86	30	25	23	4	17	38	21
39.	15- 6	70	66	69	24	1	32	15	4	59	55
40.	13-11	96	111	108	38	63	42	65	17	54	37
41.	14- 3	138	94	104	34	50	34	25	14	47	33
42.	15- 3	127	102	107	28	10	37	40	9	35	26
43.	14- 7	132	66	90	28	10	31	10	12	46	34

Appendix B

General Purpose Table - Girls

Girls	Chron. Age	I. Q. Non Lang.	I. Q. Lang.	I. Q. Tot.	English Test A Score	English Test A %ile	English Test B Score	English Test B %ile	Color Pre-Test	Color Fin. Test	Color Growth
1.	13- 9	132	114	118	41	70	40	60	34	70	36
2.	15- 6	80	76	78	29	20	26	6	23	73	50
3.	13-11	95	89	92	35	53	40	60	43	85	42
4.	15- 0	89	90	90					21	35	14
5.	14- 6	67	95	82	48	88	39	55	33	62	29
6.	14- 1	86	113	105	33	40	34	25	17	86	69
7.	13-10	107	74	90					28	75	47
8.	14- 5	89	112	106	53	96	45	75	38	82	44
9.	14- 7	94	70	83	29	20	22	3	28	48	20
10.	14- 8	121	100	105	29	20	28	7	30	65	35
11.	14- 2	105	107	107	31	30	32	15	31	63	32
12.	13- 9	109	112	112	36	56	43	67	27	58	31
13.	14- 5	133	109	113	30	25	36	35	31	78	47
14.	14- 9	97	95	95	30	25	36	35	11	72	61
15.	14- 3	110	67	86	29	20	32	15	29	59	30
16.	15- 0	89	95	93	29	20	35	30	25	49	24
17.	13-11	127	116	118	37	60	36	65	36	90	54
18.	14- 4	89	92	91	32	35	32	15	29	58	29
19.	14- 8	88	106	101	39	66	32	15	31	69	38
20.	14- 7	83	90	87	39	66	35	30	30	70	40
21.	15- 2	109	105	107	37	60	33	20	28	66	38
22.	15- 7	84	95	91	30	25	30	9	26	42	16
23.	15- 6	109	100	101	31	30	35	30	29	56	27
24.	15- 7	101	91	94	29	20	37	40	32	66	34
25.	16- 0	93	70	80	28	10	35	30	27	60	33
26.	15- 1	131	74	91	27	7	32	15	22	58	36
27.	15- 4	115	83	90	28	10	20	1	18	62	44
28.	14- 2	71	78	74	31	30	32	15	21	69	47
29.	14- 6	102	112	111	37	60	43	67	39	92	53
30.	14- 7	136	81	97	30	25	42	65	23	76	53
31.	14- 0	83	107	98	29	20	33	20	21	67	46
32.	14- 4	81	119	108	51	94	49	85	44	86	42
33.	15- 0	77	89	84	38	63	35	30	21	52	31
34.	14- 8	97	111	109	28	10	36	35	25	52	27
35.	13-10	109	118	116	35	53	46	77	31	60	29
36.	16-10	89	97	95	33	40	35	30	28	59	31
37.	14- 8	79	108	97	36	56	29	8	18	39	21
38.	13-10	89	94	92	33	40	40	60	39	85	46
39.	14- 5	122	120	121	33	40	44	70	31	72	41

Exposure Data on Natural Color Photographic Transparencies

The colored pictures used in this study of Color in Our Lives were taken by the author with a Kodak 35 with a 3.5 lens and a built-in range finder. A Weston exposure meter was used as a guide to correct exposure. In listing exposure data below, the type of film used will be indicated by K. for Kodachrome and A. for Ansco. This set of duplicate transparencies was made by Eastman Kodak Company of Rochester, New York.

Slide

1. Title slide: Color in Our Lives.

   K., 1/50 second at f:11.

2. All the Spectrum Hues in Nature, (Mt. Chocorua, N. H.) A., 1/50 second at f:6.3.

3. Fireworks.

   A., bulb, about 30 seconds, camera held in hand.

4. Danny Boy.

   K., 1/50 second at f:9.

5. Stained Glass Window, (in Boston University, Boston, Mass.) A., 10 seconds at f:5.6.

6. Diagram of Prism and Spectrum.

   K., 1/50 second at f:11.

7. Spectrum Colors.

   K., 1/10 second at f:5.6, with #2 portra lens, at 18 inches.

8. Electromagnetic Spectrum.

   K., 1/50 second at f:7.

9. The Color Circle.

   K., 1/50 second at f:7.

10. Hue, Value and Chroma.

    K., 1/50 second at f:7.

11. Nasturtium Garden.

    A., 1/50 second at f:4.

12. Diagram of the Eye.

    K., bulb, 2 seconds at f:5, with 2 #2 daylight photoflood lights.

13. Pseudo-Isochromatic Test for Color Perception.

    K., 1/10 second at f: 4.5, with #1 portra lens and 2 #2 daylight photoflood lights.

14. Holmgren Color Test.

    K., 1/10 second at f:3.5, with #1 portra lens and 2 #2 daylight photoflood lights.

15. Colors on the Whirling Machine.

    K., 1/10 second at f:16.

16. Whirling Machine in Motion.

    K., 1/10 second at f:16.

17. Red Cellophane.

18. Green Cellophane.

19. Blue Cellophane.

20. Primary, Secondary and Tertiary Colors.

    K., 1/50 second at f:7.

21. Campfire, (Harold Parker Reservation, Andover, Mass.) K., 2 seconds at f: 3.5.

22. Snow Ghosts.

K., 1/50 second at f:12.

23. Vibrating Colors.

K., 1/10 second at f:11.

24. Poinsettia.

K., 1/10 second at f:6, with #3 portra lens and 2 #2 daylight photoflood lights.

25. Vermont Countryside, (Stowe, Vermont.)

K., 1/50 second at f:7.

26. Orange Zinnias.

K., 1/25 second at f:8.

27. Golden Wedding Cake.

A., bulb, 1 second atf:8, with #1 portra lens and 2 #2 daylight photoflood lights.

28. Green of the Pine.

A., 1/25 second at f:4, with # 3 portra lens.

29. Blue of the Sea and Sky, Hampton Beach, N.H.)

K., 1/50 second at f: 11.

30. Orchid.

K., 50 seconds at f:22, with #3 portra lens and 2 #2 daylight photoflood lights.

31. The Bride.

K., ½ second at f:4.5, with 2 #2 daylight photoflood lights.

32. Our Flag.

K., 1/50 second at f:8.

33. Winter Sunrise.

K., 1/10 second at f:3.5.

34. A Cold Sunset.

K., 1/25 second at f:3.5.

35. Rainbow.

K., 1/50 second at f:5.

36. Early Azalea.

K., 1/50 second at f:5.6.

37. Turk's Cap Lilies.

K., 1/25 second at f:5.6.

38. Fall Foliage.

A., 1/50 second at f:7.

39. Promethea Moth Caterpillar.

K., 1/25 sec. at f:11, with # 3 portra lens.

40. Nest and Young of Oven Bird.

K., 1 second at f:11, with # 3 portra lens.

41. Spacious Skies, (Hampton Beach, N. H.)

K., 1/50 second at f:11.

42. The Storm.

K., 1/25 second at f:5.

43. Colored Pictures.

K., 1/50 second at f:8.

44. Nest and Eggs of Hermit Thrush.

K,. 5 seconds at f:12.7 with #1 portra lens

45. Sun Star.

K., 1/25 second at f:6.3 with #3 portra lens.

46. Grandfather.

K., ½ second at f:4.5 with 2 #2 daylight photflood lights.

47. Little Ellen.

K., 1/50 second at f:3.5

48. Color Harmonies.

K., 1/50 second at f:5.6

49. Complementary Color Harmony: Poinsettia.

K., 1 second at f:5.6 with #1 portra lens and 2 #2 daylight photoflood lights.

50. Analagous Color Harmony: Barberry Blossoms.

K., 1/50 second at f:8.

51. Monochromatic Color Harmony: November Bouquet.

A., bulb, ½ second at f:7, with #1 portra lens and 2 #2 daylight photoflood lights.

52. Colors for a Hooked Rug.

A., bulb, 1 second at f:7, with #1 portra lens and 2 #2 daylight photoflood lights.

53. 9' by 12' Hooked Rug.

A., bulb, 2 seconds at f:8, with 2 #2 daylight photoflood lights.

54. McArthur Garden.

K., 1/50 second at f:5.6.

55. Detail of McArthur Garden.

K., 1/50 second at f:5.

56. Interior.

K., bulb, 2 seconds at f:8, with 2 #2 daylight photoflood lights.

57. Party Gowns.

K., bulb, ½ second at f:4.5, with 2 #2 daylight photoflood lights.

58. Colors in Our Schools.

K., 2 seconds at f:5, with 2 #2 daylight photoflood lights.

59. A Colorfull Classroom.

K., 2 seconds at f:5, with 2 #2 daylight photoflood lights.

60. Twilight Colors.

A., bulb, 1 second at f:3.5.

Interest Inventory

1. Name _____ Address _____

2. Do you have any difficulty in studying Science? _____

3. If so, explain. _____

_____

5. Why did you elect Science? _____

_____

6. What school subject do you like most? _____

7. " " " " " " least? _____

8. In what school activities do you participate? _____

_____

9. Do you have a hobby or special interest? _____

10. If so, describe it. _____

_____

11. What else do you do in your leisure time? _____

_____

_____

12. How old are you? _____ years _____ months.

d/ _____ g/ _____ j/ _____

e/ _____ h/ _____ k/ _____

f/ _____ i/ _____ l/ _____

m/ _____

Key to Interest Inventory

a. Division or class, of Science pupils.

b. Number in alphabetical arrangement of division.

c. Number in alphabetical arrangement of three divisions of Science students.

d. Chronological age.

e. Mental age.

f. I. Q.

g. Achievement - grade level.

h. English comprehension test - percentile position in entire freshman class of 218 pupils.

i. I. Q. percentile position in entire freshman class.

j. Pretest on Color (number of correct answers).

k. Final test on Color (number of correct answers).

l. Growth in this area.

m. Growth in this area - numerical position in Science group of 83 pupils.

STIMULATING

AROUSING

CHEERING

QUIETING

SOOTHING

1. Color the border of this page, starting with red for arousing, orange for cheering, yellow for stimulating, green for quieting, blue for soothing, and violet for subduing. Blend the two neighboring colors together between the terms.

2. What color or colors do you like best for each of the following purposes: your clothing, your living room, your kitchen, your bedroom, your house (outside), your car, your school room, and flowers or pictures to be enjoyed?

3. Explain how you can see the flame of a burning candle.

4. Explain how you can see the paper on which you are writing.

5. Explain how you can see the stained glass window in your church.

6. Draw a diagram to show what happens to a ray of sunlight when it passes through a prism.

7. What does "refract" mean?

8. What color is refracted most in passing through a prism?

9. What color is refracted least in passing through a prism?

10. Light waves are electromagnetic waves of energy. What other electromagnetic waves can you name?

11. What are ultraviolet rays?

SUBDUING

12. What are infrared rays?

13. What is the spectrum?

14. In the spectrum the colors are not found in equal parts. Which color occupies the greatest area? Which is found in the smallest area?

15. What is a spectroscope?

16. What is a spectrophotometer?

17. About how many tints and shades of the various colors can be distinguished by the human eye? How many can be distinguished by the spectrophotometer?

18. In the scientific measurement of color, what three qualities are considered?

19. Explain the meaning of the term, "hue", and give four examples. (Colored illustrations are best.)

20. Explain the meaning of the term, "value", and illustrate your answer.

21. What does chroma mean? Make a little sketch which shows variation in chroma.

22. What is color? Can there be color without the presence of an eye and brain?

23. Briefly explain the theory of how we see color.

24. If an opaque object appears to be blue, what colors are being absorbed and what reflected?

25. Answer the same question for green, yellow and purple objects.

26. If stained glass appears red, what colors are being absorbed and what are transmitted?

27. Answer the same question for blue green and orange glass.

28. If you were color blind what difficulty would you have?

29. Is there any kind of work which should be avoided by colorblind people? Why?

30. In stage lighting, what colored spot lights may be added to produce white light.

31. What are the primary colors in lights?

32. What effect is produced by addition of colors when the spectrum colors from a prism are passed through a second prism?

33. What happens when the spectrum colors are blended on a rotating machine?

34. Why does the mixing of pigments produce the subtraction of colors?

35. Name and illustrate the primary colors in pigments.

36. What are the secondary colors? Illustrate your answer.

37. Give four examples of intermediate colors. Illustrate.

38. What is meant by a tertiary color? Mix paints to produce a tertiary color.

39. When light is transmitted by green glass, what subtraction has taken place? Answer the same question for purple glass.

40. Are absorption and subtraction of color the same?

41. Why are warm colors so called? Name or illustrate them.

42. Why are cool colors so called? Name or illustrate them.

43. What are advancing colors? receding colors?

44. What effect is produced when brilliant red and green are placed side by side?

45. How do you explain the effect known as after image? Where have you seen one other than in the lesson?

46. Referring to the border on Page 1, list the emotional effects which are thought to be produced by each color.

47. How are colors used by some doctors in treating patients?

48. List the characteristics or ideas which are symbolized by each of the spectrum colors and brown, black, white, gold and silver.

49. Explain the symbolism of the colors in our flag.

50. What causes the brilliant colors of the sunrise and sunset?

51. Explain the formation of a rainbow.

52. What produces the green coloring in leaves?

53. Explain one theory by which scientists account for the autumn colors of leaves.

54. Why do the sky and large bodies of water appear to be blue when we know that air and water are both colorless?

55. What causes the color in flowers?

56. List some of the most colorful insects. Make colored sketches of two or three of them, if you wish.

57. How do we account for the colors in the feathers of birds?

58. What is irridescence? How is it explained scientifically?

59. In printing colored pictures for calendars, magazines, etc., what process is used? Explain it briefly.

60. What is meant by a color harmony?

61. Give examples or illustrations of complementary, monochromatic and analagous color harmonies.

62. Study the color harmony of the predominating colors on one room of your home and describe it here.

63. Where do we use warm colors in the home? cool colors? Why?

64. What color harmony do you like best in your clothing? If you know why you like it best, explain.

65. Make a list of the uses of color - just as many as you can think of - in our homes, schools, industry and all around us.

66. In what colors would you like to see this classroom painted? Why?

67. List some of the advantages of color photography.

68. Explain, as briefly as possible, the color photography process by which we make slides, like those used in class, and the many colored movies which we enjoy so much today.

1. Design a suitable and attractive cover for your study of Color In Our Lives.

2. Make a special study of The Sources of Pigments and Dyes.

   List the various colors and give the sources from which we obtain the coloring material for each. Tell any interesting incidents which you may find regarding the discovery of any of these materials. References: Rustanoby, J.H., Principles of Color and Color Mixing, Mc-Graw Hill, New York, 1947, pages 9 to 17.

3. Make a list of the various Media of Expression in Color and write one or more sentences about each. Illustrate as many as possible, if you wish.

4. Experiment, just for fun, with one or more of those media. Include the results of your experiments in your notes if you can.

5. A. Plan the color scheme for a room in your home. Arrange the samples of the colors on a full page, arranged in a manner similar to this diagram.

   B. On a second page, show the colors to be used in furniture and other accessories.

6. Plan color schemes for all the rooms of your home and show sample colors in arrangements similar to this one suggested for 5A. Explain why certain colors are selected for each room.

7. Plan the winter wardrobe you would like to have, showing color harmonies for dress clothes, school clothes, and sport clothes.

8. Find, and mount in your notebook, pictures which show protective coloration.

9. Arrange a page showing spectrum and intermediate colors illustrated by flowers. You may sketch the colored pictures of flowers or cut them from magazines and seed catalogs.

10. Arrange a page showing all of the colors illustrated by fruits or vegetables.

11. Experiment with color photography yourself.

12. Arrange a series of samples of cloth, wall paper, or other materials and tell the color harmonies you find in them.

13. What other possibilities can you see for the use of colored slides like those shown in this study of color?

14. Make colored sketches to show Color in Nature.

15. Plan a flower garden. Draw a plan showing the flowers to be used and the color scheme they will present.

16. Plan the design and show color harmony to be used in an afghan, bed spread, cloth for overdrapes or any other purpose, an automobile (outside and inside), wall paper, or any other product which must be designed before being manufactured.

1. Beauchamp, Mayfield and West, Science Problems, Book 3 Scott Foresman and Company, New York, 1938.

2. Black, N. H., College Physics, MacMillan Company, New York, 1943.

3. Butler, A.M., Foundations of Physics, M. Barrows and Company, Boston, 1955.

4. Caldwell and Curtis, Introduction to Science, Ginn and Company, Boston, 1939.

5. Caldwell and Curtis, Science For Today, Ginn and Company, Boston, 1939.

6. Clement, Collister and Thurston, Our Surroundings, An Elementary General Science, Book Iroquois Publishing Company, Inc., Syracuse, New York, 1928.

7. Davis and Sharpe, Science, a Story of Progress and Discovery, Henry Holt and Company, New York, 1943.

8. Fuller, Brownlee and Baker, First Principles of Physics, Allyn and Bacon, Boston, 1932.

9. Gruenberg and Unzicker, Science in Our Lives, World Book Company, New York, 1938.

10. Hunter and Whitman, Doorways to Science, American Book Company, Boston, 1947.

11. Hunter and Whitman, My Own Science Problems, American Book Company, Boston, 1935.

12. Hunter and Whitman, Problems in General Science, American Book Company, Boston, 1930.

13. Lincoln Library, Frontier Press Company, Buffalo, New York, 1926.

14. Powers, Neuner, Bruner, and Bradley, Using Our World Ginn and Company, Boston, 1941.

15. Stewart, Oscar M., Physics, A Textbook For Colleges, Ginn and Company, Boston, 1944.

16. Stewart and Cushing, Physics For Secondary Schools, Ginn and Company, Boston, 1941.

17. Watkins and Perry, Science for Human Control, MacMillan Company, New York, 1940.

18. Webster's New International Dictionary, G. and C. Merriam Company, Springfield, Massachusetts, 1937.

19. Willard, Lester R., Experiences in Physics, Ginn and Company, Boston, 1943.

20. Wood and Carpenter, Our Environment, How We Use and Control It, Allyn and Bacon, Boston, 1937.

DICTIONARY OF COLOR TERMS

You may fill in the definitions of these terms as you learn them in the lessons on Color In Our Lives.

absorb

achromatic

addition of colors

advancing colors

analagous colors

blending

bright

brilliant

chroma

color

color circle

color harmony

complementary colors

real colors

dark

deep

diffused light

dominant color

dull

full color

hue

infrared

monochromatic

neutral

opaque

opposite colors

pigment

primary colors

prism

rainbow

reading colors

reflection

refraction

secondary colors

shade

spectrum

spectroscope

spectrophotometer

tint

tertiary color

transmit

transparent

ultraviolet

value

vibrating colors

vibration

vibrant colors

warm colors

wave length

COLOR IN OUR LIVES

Part 1	Part 2	Part 3	Part 4
1.	1.	1.	1. T F
2.	2.	2.	2. T F
3.	3.	3.	3. T F
4.	4.	4.	4. T F
5.	5.	5.	5. T F
6.	6.	6.	6. T F.
7.	7.	7.	7. T F
8.	8.	8.	8. T F
9.	9.	9.	9. T F
10.	10.	10.	10. T F
11.	11.	11.	11. T F
12.	12.	12.	12. T F
13.	13.	13.	13. T F
14.	14.	14.	14. T F
15.	15.	15.	15. T F
16.	16.	16.	16. T F
17.	17.	17.	17. T F
18.	18.	18.	18. T F
19.	19.	19.	19. T F
20.	20.	20.	20. T F
21.	21.	21.	21. T F
22.	22.	22.	22. T F
23.	23.	23.	23. T F
24.	24.	24.	24. T F
25.	25.	25.	25. T F

TEST ANSWERS

1 2

SCIENCE TEST COLOR IN OUR LIVES

Part I

Completion Test - In the following statements a word or phrase has been omitted. Write the proper word or phrase on the line of the same number in Column 1 of the answer sheet.

We see most objects around us by ___1.___ light.

The most restful and soothing color of all is ___2.___

When light rays are bent to a new course we say they are ___3.___

A ray of sunlight passing through a triangular prism is bent in such a way as to form the ___4.___

In the case of the prism, the ___5.___ rays are bent the most
while the ___6.___ rays are bent least

3

Color is the interpretation by the brain of the sensation caused by certain ___7.___

The measurement of color according to its position in the scale from light to dark is known as ___8.___

An object which appears green is absorbing ___9.___ light and reflecting ___10.___ light.

When mixing paints, we think of red, yellow and blue as ___11.___ colors.

Orange and yellow are known as ___12.___ colors because they are near each other and ___13.___ colors because of their apparent temperature.

Secondary colors are orange, purple and ___14.___

Blue, indigo and purple are ___15.___ when compared with the warm colors, and are called ___16.___ colors because of their appearance of being at a distance.

5 4

Part 1. (cont.)

The color which symbolizes courage and vigor is ___17.___

The colors of a sunset are caused by ___18.___ of the sunlight.

People who cannot distinguish between red and green are said to be ___19.___

When spot lights of the three primary colors are focused on the same spot, the resulting light is ___20.___

A red rose and its leaves give us a(n) ___21.___ color harmony while the yellow daffodil and its leaves show an example of a(n) ___22.___ color harmony.

When the sun's rays are refracted and reflected by the rain drops, a ___23.___ is formed.

Chlorophyll causes the ___24.___ color which we see in nature.

Blue and red paint may be mixed to produce ___25.___

Part 2

Multiple Choice Test - In Column 2 on the answer sheet place the number of the term in Column B which is most closely associated with the word in Column A.

Column A	Column B
1. Protective coloration	1. flowers 2. young birds 3. red 4. clothing
2. analagous colors	1. red& orange 2. red & green 3. red & yellow 4. red & blue
3. spectrum	1. chroma 2. value 3. hue 4. shade
4. red dress	1. red absorbed 2. orange absorbed 3. red reflected 4. green reflected
5. hue	1. black 2. yellow-green 3. white 4. colorless
6. spectrum	1. reflect 2. see 3. shine 4. refract.
7. red	1. danger 2. caution 3. pause 4. go
8. intermediate color	1. yellow 2. green 3. yellow-green 4. blue

Part 2 (cont.)

9. red, orange, yellow	1.cool 2.warm 3.receding 4.clear
10. subtraction of color	1.reflection 2. refraction 3.absorption 4. addition
11. green	1.subduing 2.cheering 3.arousing 4.quieting
12. north room	1.green 2.blue 3.rose 4.violet
13. south room	1.green 2.red 3.orange 4.yellow
14. prism	1.rainbow 2.spectrum 3.chroma 4.value
15. 50 years	1.silver 2.white 3.gold 4.orange
16. complementary colors	1.red & yellow 2.blue & orange 3. green & blue 4.yellow & brown
17. brain	1.sight 2.hues 3. interpretation 4. gray
18. color blindness	1.confusion of colors 2. lack of color sense 3.inability to see 4.addition of colors
19. green(book)	1.transmitted 2.reflected 3.absorbed 4.mixed
20. blue-green	1.primary 2.secondary 3.tertiary 4.intermediate

For the next five questions refer to the colored border around page one and give the number of the color which is

21. warm and cheerful

22. cool and restful

23. receding and subduing

24. arousing, inspiring, warm and vigorous

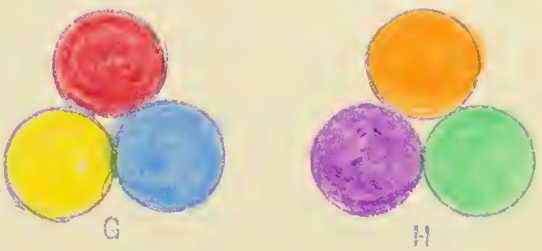
25. stimulating

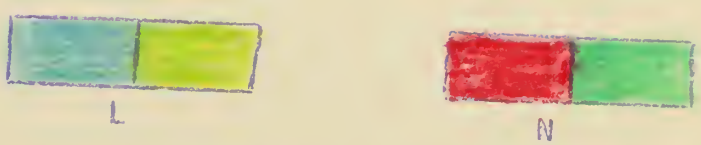
Part 2

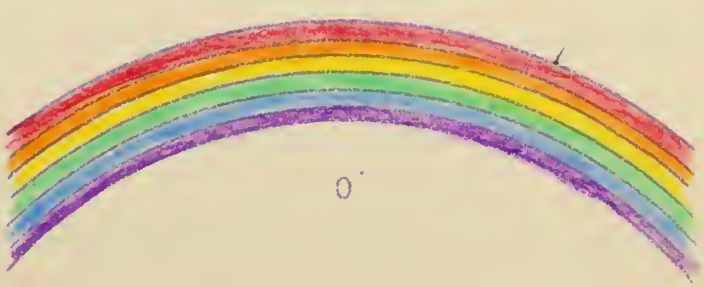
Matching Test - Read the title in column 1; then select a diagram which illustrates the title. The letter of the diagram is your answer to be placed beside the proper number in Column 2 on the answer sheet. A letter may be used more than once.

Column A

1. Complementary colors
2. Primary colors
3. Vibrating colors
4. Secondary colors
5. Spectrum colors
6. Intermediate colors
7. Warm colors
8. More than 3 hues
9. Variations in chroma
10. Cool colors
11. Value variations only
12. Advancing colors
13. Analagous warm colors
14. Receding colors
15. Rainbow colors
16. Tertiary color
17. Monochromatic colors
18. Color symbolizing envy
19. " " safety
20. " " 50 years
21. " " danger
22. " " purity
23. " " loyalty
24. Transmitted by red glass
25. Reflected by blue cloth







Part 4

True-false Test - Read each statement carefully. If you think it is true, circle the T; if you think it is false, circle the F. If you think a statement is not true, you must also supply the correct word which should go in place of the word underlined. Place your answers in Column 4 of the answer sheet.

1. Brown is called a tertiary color because it may be mixed from the three primaries.

2. When we mix violet with yellow and keep the value the same we are changing the hue.

3. Red glass absorbs red light.

4. Green grass absorbs green light.

5. An orange sweater absorbs blue light.

6. The colors seen in the flame of a campfire are known as warm or advancing colors.

7. The colors of snow and ice are cool or receding colors.

8. Color is measured scientifically by considering its hue, value and chroma.

9. According to the theory of color vision, the eye contains nerve endings, called cones, which are sensitive to the primary colors.

10. Color affects our emotions.

11. In selecting colors for our clothing we should be sure that they are suited to the purpose as well as pleasing.

12. Ultra-violet waves are shorter and travel faster than visible light waves.

13. Infrared waves are invisible but will affect some camera films.

14. Visible light waves are energy waves, like radio waves and X-rays.

15. The human eye can distinguish about 200 colors, including all tints and shades.

16. A triangular piece of glass which can separate sunlight into its spectrum colors is called a crystal.

Part 4 (cont.)

17. Primary colors in lights are the same as primary colors in pigments.

18. Green, which is found so extensively in nature, has a cheering effect upon the emotions.

19. Purple is the color of royalty, probably because it was so costly and difficult to obtain in early days.

20. Color blind persons are barred from some kinds of work because they have difficulty in distinguisking between purple and yellow.

21. If we mix red with orange, or blue with purple, we obtain secondary colors.

22. When a green coat is illuminated by a red light only the coat appears to be red.

23. Brilliant red and blue, placed side by side, seem to vibrate.

24. A piece of cloth with its design printed in three shades of brown is said to have an analagous color harmony.

25. In painting school rooms we should consider emotional effects of the colors to be used.

Date Due

MAY 11 1954		JUL 17 1957	
MAY 27 1954			
		AUG 13 1958	
JUN 12 1954		AUG 23 1958	
JUN 26 1954			
DEC 15 1954		SEP 25 1962	
JAN 22 1955			
JAN 26 1955		JUN 15 1965	
MAY 25 1955		JUL 30 1965	
JUN 22 1955			
JUL 21 1955		NOV 16 1965	
JUL 24 1956			
OCT 10 1956			
OCT 31 1956			
JAN 9 1957			

Demco 293-5

BOSTON UNIVERSITY
1 1719 02561 4795

EDI COVER
NF 59138

Service Paper
Daniels, S.L.
1949

Daniels,S.L.
Teaching the topic "color" in high school...

DATE ISSUED TO

211 746 S

055 880 S

GRAYDON JANE E
JUL 30 1965

055 880 S

GRAYDON JANE E

054 806

Service Paper
Daniels, S.
1949